Mammoth Cave National Park

Fire Management Plan

Environmental Assessment
February, 2019

PUBLIC COMMENT OPPORTUNITY

Public, or external, scoping was conducted through the National Park Service (NPS) Planning, Environment and Public Comment website where a scoping notice and document were posted on September 7, 2011, to inform the public of the proposed project. The scoping document was also sent to the Mammoth Cave National Park's mailing list to solicit feedback for the environmental assessment (EA). The public scoping period ended October 7, 2011.

As part of developing the EA, letters were mailed to the appropriate U.S. Fish and Wildlife Service offices, State Historic Preservation Office (SHPO), and tribes to introduce the project and request comments. The Draft EA reflects comments received from all entities during the public scoping period.

The programmatic Fire Management Plan (FMP) EA will be available for public comments for 30 days, December 7, 2018 through January, 7, 2019. There will also be a public meeting held at the park's Training Center on December 13, 2018 between 4:00 pm and 6:00 pm Central Standard Time.

Copies of the EA will be provided to interested individuals upon request. Reviewers should provide comments on the EA during the review period. Comments on the EA should be specific and discuss the adequacy of the analysis and the merits of the alternatives discussed. Following closure of the review period, all public comments will be reviewed and analyzed prior to release of the decision document. The NPS will issue responses to any substantive comments received during the review period and will make appropriate changes to the EA as needed.

If you wish to comment on this EA please go to: http://parkplanning.nps.gov/MACA. The "open for comment link" on the left hand side provides access to the EA. Comments can also be submitted by mail to the address below. Comments must be submitted by January 7, 2019. Comments cannot be received by email.

Superintendent
Mammoth Cave National Park
Attn: Fire Management Plan
P.O. Box 7
Mammoth Cave, KY 42259-2180

Before including your address, telephone number, e-mail address, or other personal identifying information in your comments, you should be aware that your entire comment (including personal identifying information) may be publically available at any time. While you may include in your comment direction to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

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1 Chapter 1: PURPOSE and NEED FOR ACTION

1.1 Project Background

The National Park Service (NPS) is considering actions at Mammoth Cave National Park (MACA/park) to manage wildland fire and conduct related fire management activities. The purpose of the federal action is to update the 2001 Fire Management Plan (FMP) (Olson and Caldwell 2001) with new information and to comply with the NPS's wildland fire policy directives and Director's Order (DO) 18, Wildland Fire Management. DO 18 requires that parks "with burnable vegetation must have an approved Fire Management Plan that will address the need for adequate funding and staffing to support its fire management program" (NPS 2008a). In addition, the purpose of the revision is to allow for the use of wildfire for multiple objectives, including resource benefits.

NPS Reference Manual (RM) 18 requires all parks with vegetation capable of sustaining fire develop a programmatic Spatial Fire Management Plan (SFMP) to meet the specific resource objectives for that park and to ensure firefighter and public safety are not compromised. NPS RM 18 identifies wildland fire management activities as "essential to the accomplishment of the NPS mission" (NPS 2014a: Chapter 1, pg. 4). NPS RM 18 cites the federal fire cohesive strategic goals:

1. Restore and maintain landscapes: Landscapes across all jurisdictions are resilient to fire-related disturbances in accordance with management objectives.
2. Create fire-adaptive communities: Human populations and infrastructure can withstand a wildfire without loss of life and property.
3. Respond to wildfire: All jurisdictions participate in making and implementing safe, effective, efficient risk-based wildfire management decisions.

This environmental assessment (EA) has been prepared in accordance with the National Environmental Policy Act (NEPA) of 1969 and implementing regulations, 40 CFR Parts 1500-1508; National Park Service Director's Order #12 and Handbook, Conservation Planning, Environmental Impact Analysis, and Decision-making; Section 7 of the Endangered Species Act of 1973 as amended, and Section 106 of the National Historic Preservation Act of 1966 as amended, and implementing regulations, 36 CFR Part 800

NEPA requires that every federal agency conduct an analysis of impacts for "major Federal actions significantly affecting the quality of the human environment," along with alternatives to those actions. Agencies are required to make informed decisions based on analysis conducted under NEPA and input obtained from the public and interested stakeholders. This EA complies with NEPA, the U.S. Department of the Interior's NEPA regulations (43 CFR 46), NPS DO 12, and the NPS NEPA Handbook (2015), and supplemental guidance. This EA will also be used for programmatic consultation under Section 106 of the National Historic Preservation Act and Section 7 of the Endangered Species Act.

This document provides for review of alternatives relative to the implementation of the park's programmatic SFMP. In that context, the EA generally characterizes potential fire management program operations impacts on habitat types and special features of the park, such as federal and state listed species and cultural resources. Upon completion of this EA and programmatic SFMP, project-level planning, i.e., prescribed burn plans, will be developed with more specific project-level detail.

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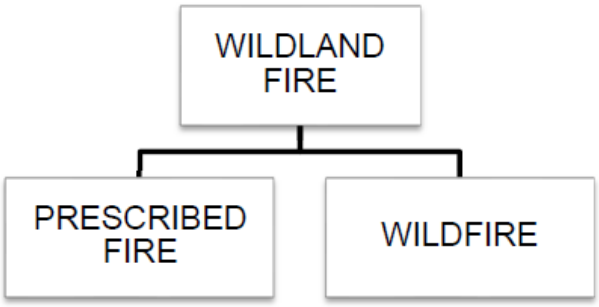
Based on the more specific details, endangered species consultation and cultural resource consultation will be conducted prior to project implementation.

The term wildland fire is used throughout this EA as defined in NPS RM 18: Wildland Fire Management (NPS 2014a: Chapter 2, pg. 1). The definition is summarized here for the reader. Wildland fire is a general term describing any non-structure fire that occurs in vegetation and/or natural fuels. There are two types of wildland fire: planned ignitions or unplanned ignitions (Figure 1). Planned ignitions are also referred to as prescribed fire or prescribed burns. Prescribed fire is any fire intentionally ignited by management under an approved plan to meet specific objectives. Unplanned ignitions are those fires not intentionally ignited by management and are also referred to as wildfire. A prescribed fire that has expanded beyond the prescribed burn plan, or escaped, is considered a wildfire. These terms are used throughout the EA and are visually summarized in Figure 1.

Figure 1: *Types of wildland fire* as defined in NPS RM 18 (NPS 2014a: Chapter 2).



Wildland fire management has a large number of terms specific to wildland fire management. These terms can change over time, therefore to see the latest definitions of terms go to: https://www.nwcg.gov/glossary-of-wildland-fire-terminology

1.2 Project Area Description

The park is located in south central Kentucky, in the counties of Edmonson, Barren, and Hart. The park is within the Second Congressional District.

The park encompasses 52,830 acres. Proposed activities associated with all alternatives will take place within the boundaries of the park. Potential cross boundary shared fire management activities is legislatively possible (Wyden Amendment (Public law 109-54, Section 434).

The park contains the world's longest known cave system and offers internationally renowned examples of karst topography. The park is noted for its outstanding scenic rivers, valleys, bluffs, forests, and abundant wildlife.

On October 27, 1981, Mammoth Cave National Park was listed by the United Nations Educational Scientific and Cultural Organization (UNESCO) as a World Heritage Site and on March 27, 1990, as an International Biosphere Reserve. In April 1996, the Mammoth Cave Area Biosphere Reserve was officially extended and now includes lands within Barren, Butler, Edmonson, Hart, Metcalfe, and Warren counties in Kentucky.

1.3 Physical Environment

1.3.1 Ecosystems

On a landscape scale, there are three functioning ecosystems in the Mammoth Cave Region including the cave ecosystem, which can be subdivided into aquatic and terrestrial components, the river ecosystem, which can be subdivided into sinking streams and base-level rivers, and the forest ecosystem, which is composed of several communities. Locally there are remnants of the prairie or barrens ecosystem that existed in the vicinity of the park prior to 1800.

The Green River, Nolin River, and other surface water bodies in the park are very important, providing habitat for mussels, fish and other aquatic species. Riparian areas provide important habitat for birds and other terrestrial species.

Sinking streams and cave streams are part of the river continuum since they are tributaries of base-level river via springs. The cave aquatic ecosystem is supported by water percolating through organic litter and soil from the forest and former barrens ecosystems. Food transport is usually down gradient, but natural back flooding from the river ecosystem through springs into the lower cave streams is also important.

The terrestrial cave ecosystem is also dependent upon the forest ecosystem for its food base. The importation of food is mostly accomplished by cave crickets, bats, and woodrats which feed outside, and use caves for refuge where their guano accumulates. Relatively minor amounts of organic material also enter the terrestrial cave ecosystem as flood deposits in normally dry passages, by gravity flow through entrances, and by animals such as raccoons, which enter caves to feed and leave their scat.

The Green River, and its tributary the Nolin River, flows 25 and 7 miles respectively through the park. These rivers possess one of the most diverse fish (82 species) and invertebrate faunas (51 species of mussels alone) in North America. The Green River is designated as an Outstanding State Resource Water and a state Wild River, providing significant scenic and recreational opportunities.

The park is located in the Interior Low Plateaus physiographic region and the over story can best be characterized as Mixed Mesophytic Forest. The park contains over 1,100 species of flowering plants, including 84 species of trees. Forest communities in the patchwork of karst terrain are determined by the amount of moisture available, which is largely determined by bedrock hydrogeology. Physiographic factors such as slope and aspect also govern the range of moisture extremes through the seasons. Cedar-oak glades naturally occur on steep dry limestone slopes that face south and southwest. These communities are where Eastern red cedar is not successional. On sunny aspects with sandstone cliffs, Virginia pine holds forth. This is the only habitat where Virginia pine is not successional. Approximately 45% of the park was open fields at the time of acquisition and the forests here are successional. On the shady moist end of the habitat spectrum at the base of sandstone cliffs are found hemlock, yellow birch, and umbrella magnolia. On shaded aspects but less steep slopes are found beech, maple, and tulip poplar. This mesic hollow community extends onto the floodplain where boxelder, silver maple, river birch, and sycamore are also prominent. On the relatively flat plateau fragments and on moderate sunny slopes, oak hickory forest-woodland is prominent where not disturbed by pre-park clearing.

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Most of the forest growth within the park is secondary, but the "Big Woods" area contains old growth stands of white oak, black oak, tulip poplar, beech, and maple. The "Big Woods" is recognized as a State Natural Heritage Site by the Commonwealth of Kentucky. (Kentucky Revised Statute 146.460)

1.3.2 Topography

The park is in the South-Central Kentucky karst region which is part of an extensive area of carbonate bedrock stretching north to Indiana, east to the Cumberland Plateau, and south to Georgia and west to the Ozarks. The park is bisected east to west by the Green River, which defines the hydrologic base-level and divides the region into two distinct physiographic areas. North of the river an alternating series of limestones and insoluble rocks are exposed with the main limestone strata accessible only near the river and in the bottom of a few deeply incised valleys. This has resulted in rugged topography with streams that alternately flow on insoluble rocks, over waterfalls, enter caves in limestone and resurface at springs perched on the next lower stratum of insoluble rock. South of the Green River the insoluble sandstone and shale cap rock over the limestone has preserved significant portions of Mammoth Cave.

1.3.3 Fire History

Nearly annual fires occurred in the barrens on the sinkhole plain to the south of what is today the park. Archaeological research has indicated that slash and burn agriculture occurred in the park's uplands in prehistoric times (Watson 1974). The slash and burn fires likely carried into the forest helping to maintain oak and hickory stands. Fire was less frequent along the Green River floodplain. Beyond the park, multiple archaeological and ecological studies have shown the importance of fire and forest management by prehistoric populations (Delcourt et al. 1998, Ison 2000). These fire regimes shaped vegetation for over 4000 years prior to European settlement when the fire regime changed as the area was settled. Indigenous people and large native grazing animals also disappeared from the landscape, both of which influenced the many plant communities. The consequences for the park include the substantial reduction of extensive prairies of fire-dependent herbaceous species becoming replaced with red cedar, scrub pine, and various oaks under a process known as ecological succession. This process of ecological succession allows fire tolerant, heliophytic plants to become replaced by shade tolerant, fire sensitive plants such as beech and maple. For these reasons, the park's use of prescribed fire is based dominantly upon prehistoric use of fire by indigenous peoples (Olson 2002), which resulted in grasslands and forest/woodlands with high biodiversity. The approximate fire return interval for oak-hickory forest/woodland is 12 years and for grasslands it ranges from 1-3 years (See map sheet 2 of the

Historical accounts are consistent with the archaeological and ecological data demonstrating active burning management of the eastern hardwoods landscape. Early travelers within the region recognized Native Americans deliberate burning of prairies and barrens along the Kentucky and Tennessee frontier, as these lands were primed for horticulture and new growth species that would attract game into open space (Michaux 1805, Hough 1878, Sauer 1927). The Cherokee tribe were specifically noted as having utilized fire in Kentucky before 1900 (Hussey 1884, Mooney 1900). James Flint, a Scot who travelled to the region by way of New York in 1818, published a series of letters describing the frontier region that now includes the park.

> "In the neighbourhood of Salt River and Green River, in Kentucky, there are extensive tracks of barren wastes. Small hazel bushes from two to three feet in height abound in these; and the quantity of nuts produced exceeds anything of the kind which I have ever seen. The soil of these wastes seems to be very similar to that of the adjoining woods; and on account of the trees diminishing gradually in size, from the forest toward the waste, it is sometimes impossible to discover a line where one stops and the other begins. This,

> together with the fact told by an old settler that some small saplings which stood on his farm twenty years ago, are now become tall trees, leads me to adopt the opinion entertained by some, that the wastes or barrens owe their characteristic form to the Indians, who set fire to dried grass and other vegetables with the design of facilitating their hunting." (Flint 1822:284).

The Fire Management Plan will facilitate the restoration of fire to those vegetation types that were historically maintained by fire. This will be accomplished primarily by using prescribed fire, but also by managing unplanned ignitions (wildfires) for multiple objectives when conditions are favorable.

1.4 Location

The park is in the state of Kentucky, approximately 100 miles northeast of Nashville, Tennessee and approximately 100 miles south of Louisville, Kentucky. See Figure 1. The park can be accessed from north and south via Interstate Highway 65.

Figure 2: *Mammoth Cave NP Vicinity Map*

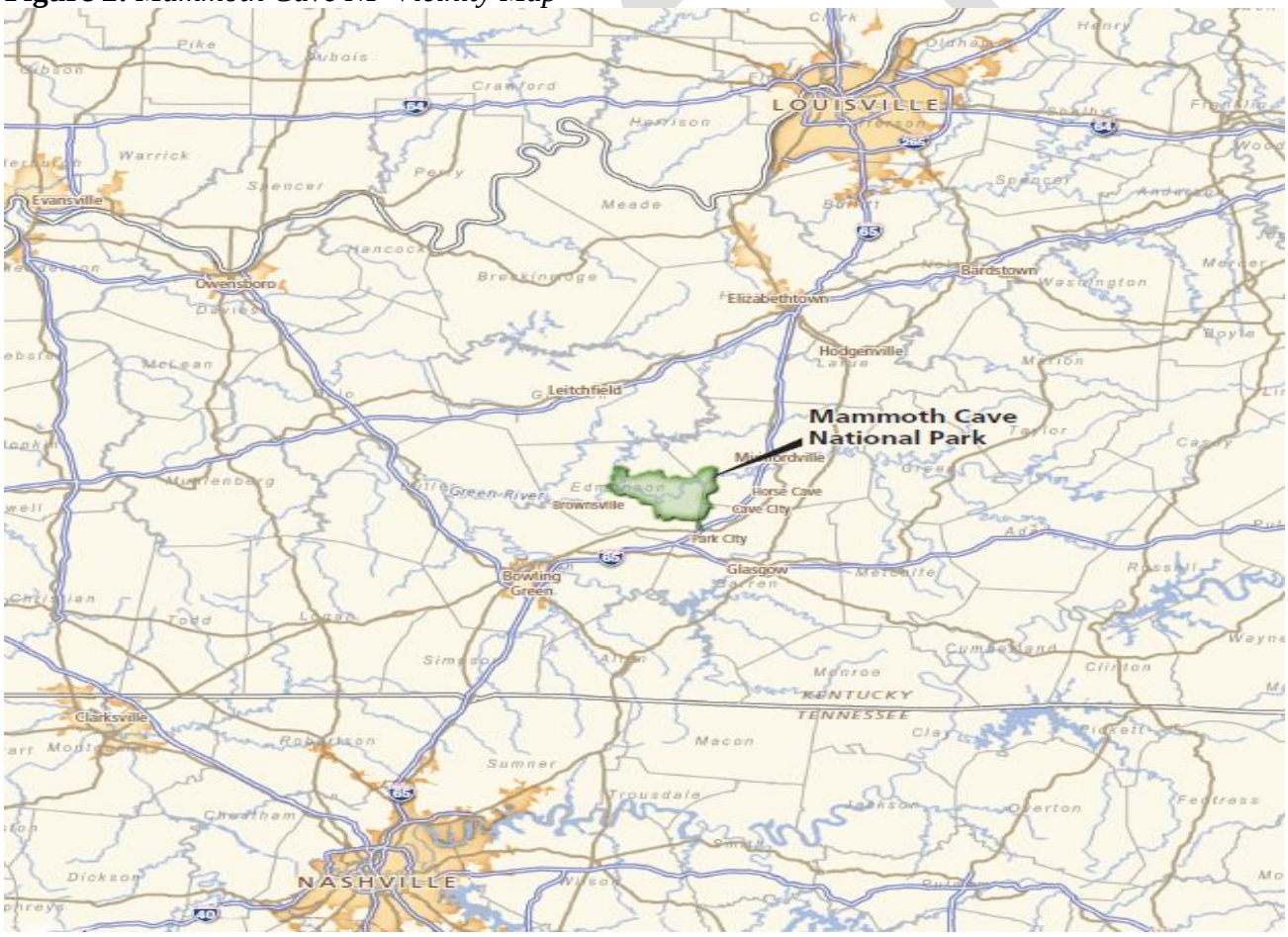
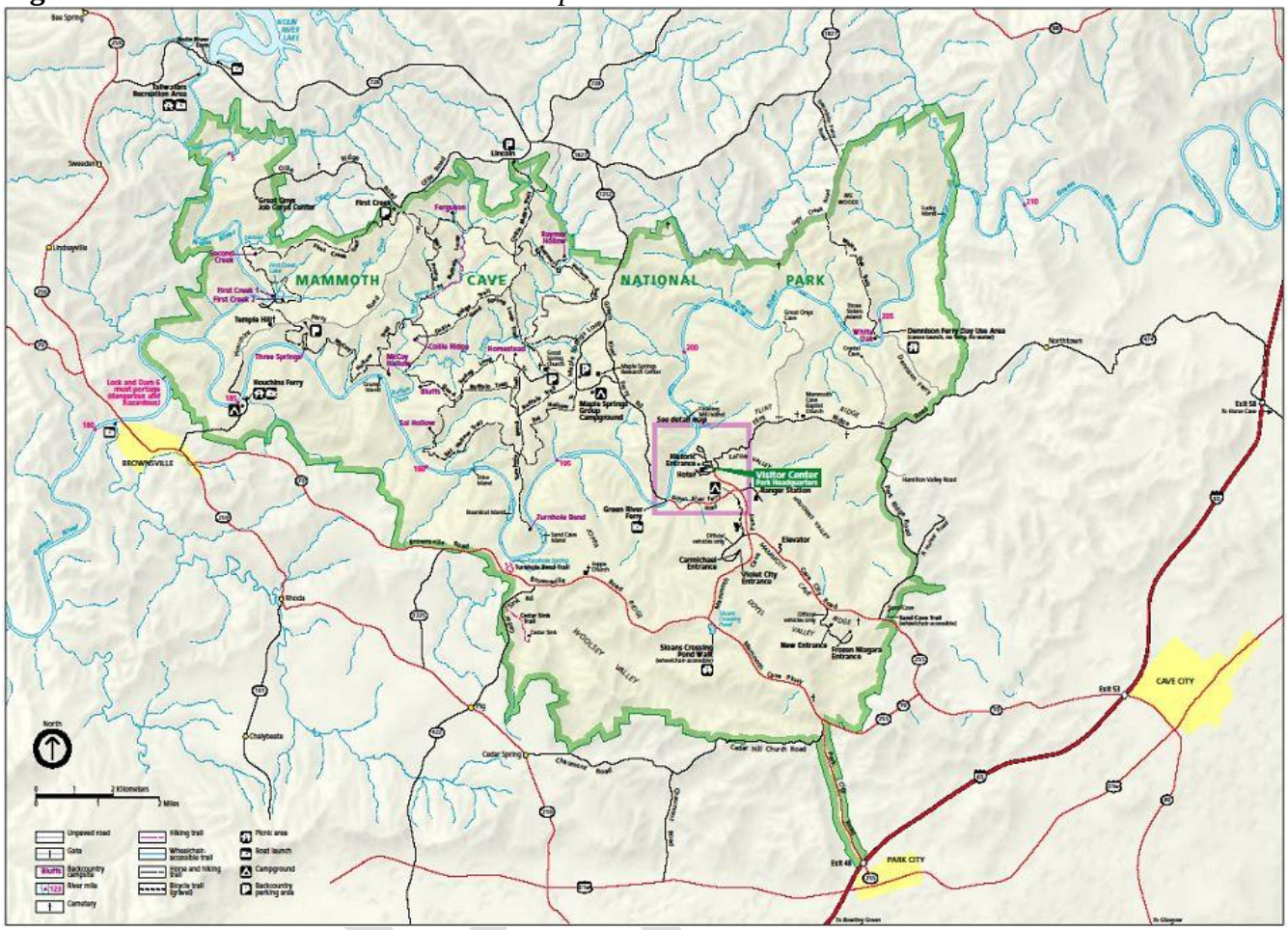


Figure 3: *Mammoth Cave National Park Map*



1.5 The Plan

The Park proposes to update its FMP as Federal, Department and Agency wildland fire management guidance and policy have changed. The NPS has made revisions and updates to RM 18, *Wildland Fire Management* (NPS 2014), to comply with the 2009 Guidance for Implementing Federal Wildland Fire Policy (U.S. Department of the Interior and U.S. Department of Agriculture 2009). This will be a programmatic wildland fire plan utilizing prescribed fire and other tools (mechanical, manual and chemical) for ecological restoration and hazard fuel reduction, and will allow managed wildfire for multiple objectives in pre-determined areas, including wildfire suppression.

1.6 Purpose and Need for the Plan

The purpose of the federal action is to update the park FMP in order to comply with the NPS's wildland fire policy directives and DO 18, *Wildland Fire Management*. DO 18 requires that parks "with burnable vegetation must have an approved Fire Management Plan that will address the need for adequate funding and staffing to support its fire management program" (NPS 2008a).

The existing FMP for the park needs to be revised to meet current NPS policies. NPS, U.S. Department of the Interior, and interagency policies have changed since the 2001 FMP was written. Revisions and updates have been made to NPS RM 18 (NPS 2014a) to comply with the 2009 Guidance for Implementation of Federal Wildland Fire Management Policy (U.S. Department of the Interior and

U.S. Department of Agriculture 2009). Federal fire policy allows wildland fires, which consist of either prescribed fire or wildfire, to be managed concurrently for multiple objectives, including resource benefit. However, wildland fires cannot be managed to accomplish resource objectives until there is an approved and current FMP. Therefore, there is a need to revise the park's 2001 FMP. Being able to utilize all current fire management strategies and tools will allow the park to more effectively achieve park ecological and hazard fuel reduction goals.

1.7 Impact Topics Retained for Analysis

The following resources (Table 1) have the potential to be affected by the proposed fire management operations associated with this plan and are therefore retained as impact topics for further analysis.

Table 1: .*Impact topics retained for further analysis*.

Impact Topic
Physical Resources Impact Topics
Air quality
Biological Resources Impact Topics
Vegetation Resources
Wildlife Resources
Species of Special Concern
Cultural Impact Topics
Archeological Resources and Cultural Landscapes

1.8 Impact Topics Considered but Dismissed From Further Analysis

The following impact topics have been reviewed and considered to have little or no permanent changes due to proposed fire management operations associated with both alternatives and are therefore "dismissed from further analysis".

1.8.1 Physical Impact Topics

Soils: The Park has a low incidence of wildfires that could impact soils. The prescribed fire program is designed to minimize impacts to soils. Prescribed burns are ignited when soil moistures are high, reducing consumption of organic material providing protection to the "A" soil horizon which reduces rainfall impacts and associated erosion. No erosion has been witnessed in the park in areas of past prescribed burns. Therefore this impact topic was dismissed from further analysis.

Water Quality: Surfactants/retardant chemicals will not be used in the park except in extreme wildfire situations and then only with permission of the Superintendent. Lack of severely burned acreage from wildfires and a prescribed fire program that is designed to minimize heat impacts to soils (no erosion entering waterways) and protection of waterway-shading vegetation (waterways remain shaded from direct sunlight keeping temperatures from rising) the NPS has determined that duration of impacts to water quality would be short with rapid recovery and therefore this impact topic was dismissed from further analysis.

***Caves*:** Research shows that fire has been an important component of the ecosystem surrounding and including Mammoth Cave. Historical observations and recent research indicate that fire played an active role in the karst region until we started putting all of the wildfires out, therefore the cave system developed and existed under a system of more frequent fires without negative effects. While caves themselves may not be impacted by fire, there is potential for fire to impact cave air quality and species which are addressed in other sections.

Additional support of acceptable impacts of fire on cave development is found in the publication: "Guidelines for Cave and Karst Protection, IUCN" 1997 International Union for Conservation of Nature and Natural Resources. A recommendation from this group is as follows:
"27. Imposed fire regimes on karst should, as far as practicable, mimic those occurring naturally." It is also worth noting that indiscriminate use of fire may have negative effects and under guideline 26 it is noted that hazard reduction burning may have negative effects on karst areas. This is not a concern at the park as all prescribed fires are designed to burn during environmental conditions of high soil moistures, ambient air temperature restrictions and other listed mitigation measures to protect the caves and cave inhabitants. See mitigation measures common to all alternatives Appendix 2.

Due to the setbacks protecting cave entrances and protection of endangered species utilizing the cave actual impacts to the cave would be minimal and therefore this impact topic was dismissed from further analysis.

***Streamflow characteristics* (hydrology):** Intense fire can cause short-term formation of hydrophobic soil layers that can increase run-off into surface streams. Wildfire intensity could be high enough to create hydrophobic soil layers. Park fire records show 11 wildfires have burned 4.7 acres since 2003. This averages to less than one (1) fire per year. Therefore actual wildfire created hydrophobic soil areas within the park is low. Proposed prescribed fire acres impact more area than wildfires. The potential for hydrophobic soil formation due to prescribed fires is low because prescribed fires are burned under environmental conditions that create less intense fire. Prescribed fires will not change infiltration rates or run-off rates appreciably throughout the burned area, although there can be small pockets of fuel concentrations that burn with enough intensity to create small areas of hydrophobic soil layers.

Due to the lack of large acreage wildfires and planned prescribed fire burns of less fire intensity with both alternatives creating minimal areas of hydrophobic soils, there will be little negative effects due to the fire program on streamflows in the park; therefore this topic was dismissed from further analysis.

***Floodplains or wetlands*:** The proposed alternatives will not affect floodplain or wetland values because no prescribed fire ignition will take place in these areas, but prescribed fire will be able to back into these areas naturally. Heavy equipment use in the floodplain/wetlands will be avoided and other impacts to floodplains/wetlands will be avoided through mitigation measures common to all alternatives, see mitigation measures common to all alternatives (Appendix 2). Additionally wildfire incidence is very minimal further minimizing fire impacts to the park, therefore this topic was dismissed from further analysis.

***Long-term management of resources or land/resource productivity*:** This impact topic addresses the long term management/use of resources and productivity (quality, quantity and diversity) potential of ecosystem functions and biodiversity, including land/soils, water, animals and plants. The proposed alternatives of the fire management program support park goals to manage natural resources, and to

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maintain, rehabilitate, and perpetuate their inherent integrity. The proposed alternatives of the fire management program are expected to result in little to no impacts on the long term management/use of resources and productivity potential of ecosystem functions and biodiversity. Therefore this impact topic was dismissed from further analysis.

1.8.2 Cultural Impact Topics

Museum collections **(objects, specimens, and archival and manuscript collections):** Museum objects include specimens, objects, and manuscript and archival collections. These are frequently kept in a museum or designated curation facility. Fire management activities will have little effect on stored collections of park artifacts. The implementation of the park's structural fire mitigation efforts will effectively reduce hazard fuels near buildings housing museum collections. The facilities that houses museum collections are surrounded by pavement. These facilities are also covered in the park's structural fire protection plan. There is no slash build up near these buildings. Due to the lack of risk to museum collections this impact topic was dismissed from further analysis.

Classified Structures: The Park contains 73 listed classified structures that includes cemeteries, old roads, churches, cave entrances, interior cave structures buildings and structures constructed by the Civilian Conservation Corps. Appendix 3 contains the current listing of classified structures located within the park. Because these are known cultural resources, fire planners with the assistance of cultural resource specialists will carry out planned mitigation measures discussed in mitigation measures common to all alternatives, Appendix 2, that will protect classified structures in operational areas from negative impacts for any planned fire management operations. Therefore this impact topic was dismissed from further analysis.

1.8.3 Social Impact Topics

Socioeconomics, including employment, occupation, income changes, tax base, infra-structure**:** The fire management program will have little impact on socioeconomics of the region surrounding the park. Proposed fire management activities generally occur during lower visitation periods or if the activities occur later in the season as proposed in Alternative 2 – Preferred Alternative they are of such short duration and few in numbers that there will be negligible affects to the regional economy. There may be a minimal increase in visitation due to an increase in grasslands/wildflowers due to restoration burning. It is felt that the increase is minimal when compared to the guided visitation associated with touring the cave. Therefore this impact topic was dismissed from further analysis.

Indian Trust Resources**:** The federal Indian trust responsibility is a legally enforceable fiduciary obligation on the part of the United States to protect tribal lands, assets, resources, and treaty rights, and it represents a duty to carry out the mandates of federal law with respect to American Indian and Alaska Native tribes. The NPS consulted with the affiliated Native American tribes to determine whether any trust resources could be impacted by implementing a fire management plan at the park. Following consultation, NPS has determined that there are no Indian Trust resources that would be affected by fire management activities. Therefore, Indian Trust Resources was dismissed from further analysis.

Non-Federal lands within Park Boundaries**:** There are a few small private in-holdings within Mammoth Cave NP. Managed cemeteries are delineated in deeds, regulations or policy. The proposed alternatives do not affect landownership or use of these sites. All private in-holdings will be protected from prescribed fire prior to start of prescribed fire ignitions. The proposed alternatives will only hinder or alter public and private access to areas in or adjacent to the park during emergency or short term planned fire management activities; therefore, this topic was dismissed from further analysis

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***Land Use*:** Land use refers to human use of land. Land use involves the management and modification of natural or wilderness into built environment such as fields, pastures, and settlements. It also has been defined as the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it. Fire management program activities have the potential to have very short-term effects on land use within and adjacent to the park, therefore this impact topic was dismissed from further analysis.

***Recreation Resources*:** The wildland fire management program is not expected to permanently change any of the recreation resources of the park. This impact topic was dismissed from further analysis.

Neighboring Lands, Urban Quality, Gateway Communities: Due to the lack of large wildfires and a prescribed fire program that considers timing of burns to minimize impacts there will not be permanent impacts to park neighbors, therefore this impact topic was dismissed from further analysis.

Human Health and Safety: In accordance with NPS Management Policies (2006), the NPS would seek to provide a safe and healthy environment for visitors and employees. Due to the emphasis placed on safety in all federal fire management policies and the current park practice of using available resources to notify the public of planned and unplanned ignitions, the revision of the FMP is not anticipated to impact public health and safety. Potential impacts of fire management on public health from the release of airborne constituents are discussed in Section 3.3, Air Quality, and potential impacts to visitor safety are addressed in Section 3.10, Visitor Use and Experience. Wildland fire management programs are designed to successfully minimize hazards to employees, visitors, and adjacent communities. With a minimal wildfire workload and a prescribed fire program designed to minimize the chance of negative impacts to human health and safety, therefore this impact topic was dismissed from further analysis.

Transportation: Impacts to transportation due to wildfires will be minimal as few wildfires occur annually and only last as long as the suppression actions are necessary. The same is true for prescribed fires. The park will monitor smoke conditions and close park roads as needed. The park will work with state and county agencies if needed to monitor potential smoke impacts to transportation systems. No permanent changes are anticipated and therefore this impact topic was dismissed from further analysis.

1.8.4 Special Designations Impact Topics

Class I Airshed Designation: The Park has been classified as a Class I Airshed under the Clean Air Act as amended in 1977 and 1990. Planned fire management activities producing smoke are closely regulated by the Commonwealth of Kentucky through their State Implementation Plan (SIP). The park follows all protocols deemed necessary by the commonwealth to minimize smoke impacts and by doing so will not impact the ability of the park to maintain its Class I status, therefore this topic was dismissed from further analysis.

Green River Designations: There are three current designations in place for the Green River, 1; *Kentucky Wild Rive*r (401 KAR 4:100) 2. *Outstanding State Resource Water* (401 KAR 10:026) and 3. *Exceptional and Reference Reach Water of Kentucky (401 KAR 10:030)*. Fire management operations associated with prescribed fire will not occur in the flood plain of the Green River. Wildfire suppression operations will have a prohibition on retardant use, and implementation of other Minimum Impacts Strategy and Tactics (MIST) will be enforced. Through planned avoidance and operational restrictions impacts to the Green River will be minimized, therefore this topic was dismissed from further analysis.

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2 Chapter 2: ALTERNATIVES

2.1 Alternatives

There are two alternatives for the Fire Management Plan EA, Alternative 1: "*No Action* ", and Alternative 2: "*Managed Fire for Multiple Objectives*" - Preferred Alternative. Alternatives were framed through discussions among Mammoth Cave National Park personnel, Southeast Region fire management and compliance staff as well as NPS Mississippi Fire Management Zone staff.

2.1.1 Mammoth Cave NP Fire Management Program Goals and Objectives (Common to All Alternatives)

Mammoth Cave Fire Management Goals and Objectives are discussed in Appendix 4: *Fire Management Goals and Objectives*.

2.1.2 Minimum Impacts Strategy and Tactics (Common to All Alternatives)

Minimum impact suppression is an increased emphasis to do the job of suppressing a wildland fire while maintaining a high standard of caring for the land. MIST tactics are utilized in all proposed alternatives. MIST guidelines are displayed in Appendix 5.

2.1.3 Suppression Chemicals (Common to All Alternatives: Use Approved by Superintendent)

Under all alternatives: Fire suppression chemicals (including foams and retardants) will not be used in the park except in the following emergency situations:

1. potential loss of human life
2. potential destruction of park developments
3. potential consumption of structures associated with identified cultural landscapes
4. potential fire escape from NPS lands into areas of Wildland Urban Interface.

2.2 Alternative 1 - *No-Action* (continuation of current fire management program)

This alternative represents a continuation of current fire management actions as developed and implemented through the 2001 FMP and associated EA; it does not mean an absence of active management of fire and fuels.

Based on definitions provided in NPS DO 12, the No Action Alternative considered in this EA would be no change in current management of the park as it relates to fire management activities. Under the No Action Alternative, the park would use its existing 2001 FMP, which is outdated because it does not reference the current Federal Wildland Fire and NPS policies. The planned activities identified in the existing 2001 FMP would continue. The 2001 FMP allows for prescribed burns to be used at the park. In the 2001 FMP the park was divided into 20 prescribed fire areas. The boundary of each of the prescribed fire areas was somewhat flexible and originally designed to accommodate a prescribed burn boundary that was defensible using minimal fireline building. Mechanical use of heavy machinery to reduce fuel loads would not be used in Alternative 1. Manual treatments to clear fuels and mowing to maintain existing defensible space around park buildings and sensitive resource sites would occur under the No Action Alternative. The management of wildland fire for multiple objectives, including resource benefit, would not occur under the No Action Alternative. Table 2 summarizes Alternative 1.

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Table 2: *Alternative 1 – No Action Summary*

Goals	1. Suppress all wildfires 2. Prescribed fire 3. Ecological restoration to change vegetation patterns/composition in fire dependent communities toward more natural patterns and composition 4. Reduce hazardous fuels
Wildfire Suppression	Full suppression with emphasis on minimizing acreage burned in the safest manner possible.
Prescribed Fire (Does not include burning slash piles)	Yes
Managed fire for multiple objectives , including resource benefit	No
Mechanical fuels reduction	No
Manual fuels reduction	Yes, up to 100 acres /ten years
Fire management use of herbicides	
Prescribed Fire Areas	20
Average Potential Prescribed Acres burned/decade*	4,350 acres

Wildfire management in the park would emphasize suppression, with the intent of keeping wildfires to minimal size. MIST (Appendix 5), would be used in all fire management operations. The management of wildfire for multiple objectives, including resource benefit, would not occur under Alternative 1.

Wildfire records for the park show that since 2003 there have been 11 wildfires burning 4.7 acres in the park with an average size of 0.43 acres. (Source: Wildland Fire Management Information Data run, June 2017)

Prescribed fire at the park is primarily used for the following ecosystem management objectives: maintain and/or restore plant communities, cycle nutrients, and reduce or remove exotic plants. It can also be used to reduce hazardous fuels. Since the park's first prescribed fire in 2002, 16,700 acres of forest, woodlands, and barrens have been treated with prescribed fire. Initial goals for the prescribed fires were to reduce the density of tree saplings in the understory and increase the cover of herbaceous herbs in the understory (Burton 2013). Burton (2013) found that after a single burn, wildland fuel loading was reduced by 18%, density of understory trees (dbh < 15cm) was reduced by more than 30%, and mean cover of graminoid species increased from < 0.01% to 5.2%.

Prescribed fire can be conducted in any of the Fire Management Units (FMU), and all prescribed fires are planned and approved consistent with the method and format required by NPS RM 18. FMUs are geographically mapped areas of the park where the same type of fire management operations are allowed. These delineations make it easier for management of the fire program within park boundaries. It is important to note that park staff work closely with Zone Fire Management staff in determining where, when and how prescribed fire operations are implemented. A list of proposed prescribed fire projects is found in Appendix 6.

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2.3 Alternative 2 Managed Fire for Multiple Objectives (*Preferred Alternative)*

The Proposed Action, the park's preferred alternative, would implement a revised programmatic SFMP for the park. The programmatic SFMP would function at the programmatic level and accommodate changes in federal wildland fire policy, guidance, and practices from ongoing improvements in the science of wildland fire management. The programmatic SFMP would provide a flexible range of options and activities that could be used to respond to changes in environmental conditions and the specific needs of fire management within the park. All actions described in the Proposed Action are consistent with the approved Mammoth Cave National Park Foundation Document (NPS 2014), related park documents, and federal NPS policy. The Proposed Action would allow for implementation of a full range of fire management activities, including wildland fire suppression, the management of wildfire for multiple objectives, and fuels management (prescribed fire/mechanical/manual treatments) within the entire park as described in the FMUs.

2.3.1 Wildland Fire Suppression Strategies

A number of wildfire suppression strategies could be available to manage unplanned wildfire in the park. Suppression activities would strive to minimize public safety threats (including firefighting personnel) and potential damage to natural and cultural resources, and would take into consideration economic expenditures, firefighting resources, and other fire priorities (local, regional, and national preparedness).

2.3.1.1 Full Suppression

Suppression is the work of extinguishing or confining a wildfire beginning with its discovery (National Wildfire Coordinating Group [NWCG] 2012). The use of full suppression does not mean that all suppressed wildfires would be small or have no impacts. Some wildfires may consume larger acreage, ranging upwards to 1,000 acres as indicated by the park's fire history described in Sec 1.3.3 *Fire History*. Full suppression efforts would be used to extinguish or control the fire in order to protect human life and property, and/or critical cultural and natural resources that are threatened by the fire. Full suppression strategies may require actions such as mop-up, defined as extinguishing or removing burning material near control lines, felling snags, and trenching logs to prevent rolling after an area has burned to make a fire safe or to reduce residual smoke (NWCG 2012). Patrol activities would also be needed to travel over a given route to prevent, detect, and suppress spot fires and extinguish overlooked hot spots (NWCG 2012).

2.3.1.2 Confine and Contain

This suppression strategy uses indirect attack to create a fuel break around a wildfire and either allows the fire to burn up to the fuel break or uses firing devices to burn out fuel between the fuel break and the flaming fire zone. Confine and contain actions often use natural barriers where possible or could use human-constructed hand lines. The use of natural barriers would potentially reduce impacts to natural and cultural resources from ground disturbance. Monitoring of fire behavior would be critical under a confine/contain strategy, and the response strategy could change in the event that objectives are no longer being met, potentially justifying a shift to a full suppression or point protection strategy. Mop-up and patrol activities are generally curtailed or limited to smaller portions of a burning/burned area than under full suppression. This is partially because these fires are larger and securing a perimeter can be accomplished without extinguishing all burning material.

2.3.1.3 Point Protection

This strategy may involve a variety of suppression tactical actions to prevent fire encroachment from threatening identified natural or cultural values at risk. Actions could include constructing fuel breaks

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or fire lines and burning them out, reducing fuel concentrations and modifying fuel continuity both vertically and horizontally, covering resources with material to shelter them from fire, and deploying water pumps and sprinkler systems. The park would work with resource advisors to determine the location of critical resources requiring protection and/or mitigated suppression actions.

Aerial resources may be used for all suppression strategies where appropriate and after evaluating techniques according to the MIST principles. This could involve aerial reconnaissance, detection, transportation of personnel and equipment, and fire control missions using retardant/bucket drops.

The park, fire managers, and incident commanders would monitor the conditions of a fire and determine if the response strategy selected needs to be revised.

2.3.1.4 Management of Wildland Fire for Multiple Objectives, Including Resource Benefits

As defined in Section 1.1, wildland fire includes both planned and unplanned ignitions. The use of planned ignitions (prescribed fire) to achieve resource benefits and/or to reduce hazardous fuels is discussed below under Section 0. Per federal wildland fire management policy, wildfires could also be managed to accomplish specific resource management goals and objectives when appropriate conditions exist. The use of wildfire to meet multiple objectives, including resource benefits, would be based on priorities identified in the programmatic SFMP, Section 3.1.3.2 *Initial Response Procedures*, as well as prescriptions contained in operational plans: programmatic SFMP Section 3.2.1.1 *Project Prioritization*. This approach would only be possible where allowing the wildfire to burn under managed conditions would not threaten life, property, and critical natural and cultural resources.

The decision to manage a wildfire, or a section of a wildfire, for multiple objectives is dependent on assessing several factors, including location, fire behavior, fuels, human values at risk, risk to firefighters, cost, weather, and resource benefits. The MACA Spatial Fire Management Plan and appendices outlines the criteria and decision factors that qualified fire specialists contemplate prior to managing a wildfire for multiple objectives. National fire policy allows part of a wildfire to be suppressed (e.g., approaching a community), while allowing another flank to burn (e.g., approaching undeveloped forest habitat).

Wildfire could be used to reduce hazardous fuels, restore fire in fire-adapted ecosystems, improve wildlife habitat, and restore native vegetation. Managing unplanned ignitions for resource objectives would require continuous monitoring, MIST, and use of resource advisors to ensure that critical natural and cultural resources are not negatively impacted. Wildfires managed for multiple objectives would be suppressed so that it did not cross outside the park boundary.

2.3.2 Fuel Management Strategies

Fuel management strategies considered within this EA include the use of prescribed fire, mechanical and manual fuel treatment, as described in detail below. Under the Proposed Action, prescribed fire, mechanical and manual treatments would be used in areas identified by the park in the programmatic SFMP's multi-year fuels treatment plan. Annual coordination with the interdisciplinary team, subject matter experts, and external stakeholders would provide valuable input for flexible management of the fire management program as needed. The multi-year fuels treatment plan would be reviewed and updated annually in response to factors such as changing federal regulations and guidelines, fire effects monitoring results, lessons learned in the field, budgets, staffing needs, and administrative changes within and outside the NPS. Per RM 18, updates and modifications to the multi-year fuels treatment plan may or may not be made annually, but the plan should be reviewed during the annual update to

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ensure that project prioritization and proposed implementation schedules are current and consistent with environmental compliance requirements. Initial planning efforts by the FMP interdisciplinary team have identified a fuel treatment goal of approximately 100-1,200 acres per year, using both mechanical/manual treatments and prescribed fire. This goal may change from year to year depending on available funding and other resources.

2.3.2.1 Prescribed Fire

The park has identified that prescribed fire may be a useful tool for the following uses:

1. Restoring natural ecological processes;
2. Protecting natural and cultural resources; and
3. Managing cultural landscapes.

Prescribed fire would be planned and prioritized annually by the park, before being used as a tool, and individual prescribed burn plans would be developed that adhere to the guidelines set forth in the programmatic SFMP. Each prescribed burn plan would need to be approved by the park superintendent. Treatment boundaries identified within the site-specific prescribed burn plan could correspond with existing features on the landscape, such as roads and waterways, but may also include a hand line that is created along the park boundary or to connect existing features. Treatment unit boundaries could also be augmented by mechanical/manual means to improve firefighter safety during fire operations by reducing fire intensity along the treatment edge, thereby creating areas to facilitate containment and control. Each prescribed fire would be managed and monitored by qualified personnel prior to and during all operations until the fire is declared to be extinguished. Each prescribed burn plan would specify ignition tools and patterns, which would be ground or aerially based and could include use of mixed gasoline and diesel fuel in drip torches, "fusees," flares fired from handheld pistols, gelled gasoline, and incendiary plastic spheres. This list does not preclude the use of new ignition tools developed during the life of the programmatic SFMP. Prescribed burns that exceed the scope of the approved prescribed burn plan would be managed as wildfires. The appropriate compliance would be completed for the prescribed burn plan.

The Park plans to burn up to approximately 1,200 acres annually under the FMP to improve wildlife habitat, manage and encourage regeneration of desired oak-hickory forest types, manage grassland and old field habitats, aid in the recovery of native flora, reduce fuel loads, and control/reduce the encroachment of undesirable species. Prescribed burning will also be used to maintain and manage areas seeded with native grasses to remove woody vegetation, promote growth, enhance species diversity, and prepare sites for follow-up herbicide applications to remove invasive species.

The amount of prescribed burning is expected to vary each year based on weather conditions. The majority of prescribed burning will be conducted from January to March; however, burning may continue into April if suitable burning conditions allow. Fall and late growing-season burns may also be needed to reduce the encroachment of woody vegetation and invasive species in native grasslands, early successional habitat, and forested habitat. This burning will generally be conducted between mid-October and January. The Park could conduct prescribed burning to approximately 200 acres April 1 to April 30, approximately 400 acres August 1 to November 14, and approximately 1,200 acres November 15 to March 31. However, the annual acres of prescribed burning, when combined, will not exceed approximately 1,200 acres per year. No prescribed burning will occur from May 1 to July 31.

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2.3.2.2 Mechanical, Manual, and Chemical Fuel Treatment

Mechanical, manual and chemical fuel reduction methods would be used as needed and where appropriate to prepare for prescribed burns. Mechanical fuels reduction uses machinery such as masticators and manual fuels reduction includes people clearing fuels using mowers, chainsaws, hand tools, etc. Pile burning could be associated with either mechanical or manual. Both mechanical and manual fuel treatments could be used to reduce fuels along burn area boundaries, around sensitive resource areas (for example cultural resources or sensitive wildlife habitat) and park facilities. Mechanical and manual fuel treatment would also be used to enhance prescribed fire in attaining programmatic SFMP objectives. Chemical use would be limited to park approved herbicides.

Thinning of vegetation in order to reduce fuels would be accomplished using hand-operated power tools and hand tools, such as chainsaws or other cutting tools, and wheeled or tracked mechanized equipment such as tractors, masticators, and similar equipment to construct control lines, create fuel breaks, thin fuels, and clear vegetation, including nonnative species. Heavy equipment that uses large tires or large tracks resulting in less ground disturbance would be the first choice for use. Projects that require equipment with possible ground-disturbing effects would be planned and implemented with mitigation measures (Appendix 2) when resource conditions allow for reduced impacts to soil, vegetation and potential archeological sites.

Vegetation thinning would reduce the fuel load available to reduce fire intensities of either a prescribed fire or wildfire. Fuel reduction could be used alone to reduce the intensity of a potential wildfire or it could be used prior to a prescribed burn to minimize the intensity and help maintain control of the fire. The need for using fuel reduction techniques would be determined in consultations among NPS resource management specialists, fire ecologists, and a fire management officer.

Each year the park proposes to accomplish mechanical fuels reduction treatment of documented hazardous fuels or as stage one prep-work for prescribed fire projects. Under Alternative 2 mechanical fuels reduction projects consist of masticators, bush-hogs, and other types of machinery that reduce and compact fuels on-site. The estimated mechanically treated acres are approximately 500 acres per 10 year period. Access restrictions to the public are possible during mechanical treatment projects.

Alternative 2 also proposes manual fuels reduction projects. Manual fuels reduction activities: use of mowers, chainsaws, weed whackers and other handtools, are proposed to occur on approximately 100 acres/10 years. These projects would be in wildland urban interface areas and other areas where the reduction of fuels is deemed necessary. Heavy equipment that uses large tires or large tracks resulting in less ground disturbance would be the first choice for use.

2.3.2.3 Herbicide Treatment

Alternative 2 utilizes application of herbicides to control invasive vegetative species, mesic species or other unwanted species that have invaded post-burn disturbed sites within the boundaries of a burn project or wildfire zone. Spot applications would target invasive plants specifically. Pre-treatment of invasive species prior to ignition of management developed burn areas is possible where warranted. Fire managers will follow NPS operational guidance and standards which call for any application of herbicides to be pre-approved and applied by qualified personnel. Estimated herbicide spot application would occur on approximately 1,500 acres/ 10 years under this alternative.

The goal of Alternative 2 is the same as the Alternative 1: ecological restoration to change vegetation composition in fire dependent communities toward more natural patterns and composition and to

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reduce hazard fuels in areas cooperatively identified by park staff and zone fire management staff. Table 3 summarizes Alternative 2.

Under Alternative 2, the park is divided into 2 fire management units (FMUs): FMU1 covers all areas of the park where managing fires for multiple objectives is allowed. All fire management tools are allowed in FMU 1: managed wildfire for multiple objectives, prescribed fire (broadcast fire and pile burning), handpiling fuels, mastication/brush hogging and applications of herbicides to control invasive plant species and other unwanted species in disturbed fire areas. FMU 2 encompasses areas of the park where the use of fire for multiple objectives will not be allowed and aggressive control of all wildfires is required. These are, wildland urban interface areas, a ¼ mile strip in from the boundary of the park and other areas including visitor use/developed areas that the park wants to protect from wildfire, all other fire management tools are allowed.

Fire Management Actions used in Alternative 2 are the same as Alternative 1 with the following additions:

1. Clearing vegetation: mechanical removal of vegetation (hazard fuels) near structures or other valued park infra-structure. Generally piled and burned, lopped and scattered or chipped and removed from the site, may be masticated with a mastication machine.

2. Use of herbicides: where appropriate fire managers may use herbicides to spray unwanted vegetation. After the plants die they are then burned. This type of burning works in eliminating specific unwanted plant species.

The Proposed Action would be implemented to achieve the following objectives:

1. Ensure firefighter and public safety during every fire management activity;
2. Suppress all unwanted and undesirable wildfires;
3. Use prescribed fire as a tool to manage vegetation and wildland fuels;
4. Modify fuel complexes around developed areas, along wildland urban interface boundary areas, and in proximity to cultural sites;
5. Integrate fire as a natural process into the park's ecosystem to the fullest extent possible;
6. Facilitate reciprocal fire management activities through the development and maintenance of cooperative agreements;
7. Manage prescribed and wildfires in concert with federal, state, and local air quality regulations; and
8. Promote public understanding of fire management programs and objectives.

All fire management activities, including non-fire fuels treatments and prescribed burns, would be implemented using review and planning procedures in accordance with NPS DO 18 and RM 18. The programmatic SFMP includes a multi-year fuels treatment plan, which would be reviewed and revised by the park on an annual basis utilizing updated information on factors such as fuel loads, climatological conditions, funding levels, and policy changes. Proposals for fuel treatments would be identified in the multi-year fuels treatment plan. Individual non-fire treatment or prescribed burn plans would be completed for each project. All proposed fire management activities would be consistent with the objectives identified in the programmatic SFMP. If fuels management projects deviate from this programmatic SFMP/EA, those projects would undergo separate and independent review prior to approval in accordance with NPS RM 18 and would be subject to additional NEPA review.

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Prescribed fire would be used as a tool to restore and maintain fire-adapted natural vegetation communities and to reduce hazardous fuel accumulations in and around cooperatively selected natural and cultural resources in the Park. All prescribed fire projects will be developed cooperatively between park and zone fire management staff. Some removal of hazardous fuels would be done to reduce the fire danger near structures and along the park boundary where private property, houses and other structures are determined to be at risk from wildfires under normal weather conditions. Hazard fuel reduction projects will be developed cooperatively between park and Mississippi Zone fire staff. Areas under the Alternative 2 multi-year treatment plan would have prescribed fire, mechanical and manual fuels treatment projects proposed over the next 10 years. Proposed prescribed fire burn acres, including pile burning, could cover approximately 1,000 - 12,000 acres over the next 10 years.

Alternative 2 proposes projects from the multi-year treatment plan covering approximately 12,000 acres (all projects). Appendix 7, as well as the programmatic SFMP with its accompanying mapsheets lists the proposed multi-year fuels treatment plan. The project list will be updated during the fire management plan annual update process.

Table 3: *Alternative 2: Preferred Alternative Summary*

Goal	• Suppress all unwanted wildfires • In FMU 1 manage fire to change vegetation composition in fire dependent communities • Reducing hazard fuels
Wildfire Suppression	FMU 1 Suppress all unwanted wildfire FMU 2 Suppress all wildfire
Prescribed Fire (Includes burning piles)	Yes
Managed Wildfire for Multiple Objectives	Yes
Mechanical Fuels Reduction	Yes
Fire Management Use of Herbicides	Yes
Fire Management Units	2
Average Prescribed Acres burned/decade	Approximately 10,470 acres
Proposed Mechanical Treatment Acres/decade	Approximately 500 acres
Proposed Manual Fuels Treatment acres/decade	Approximately 100 acres
Potential Herbicide Application Acres/decade	Approximately 1,500 acres

Figure 4 shows the fire management units associated with this alternative. Appendix 7 lists the proposed project sites for this alternative.

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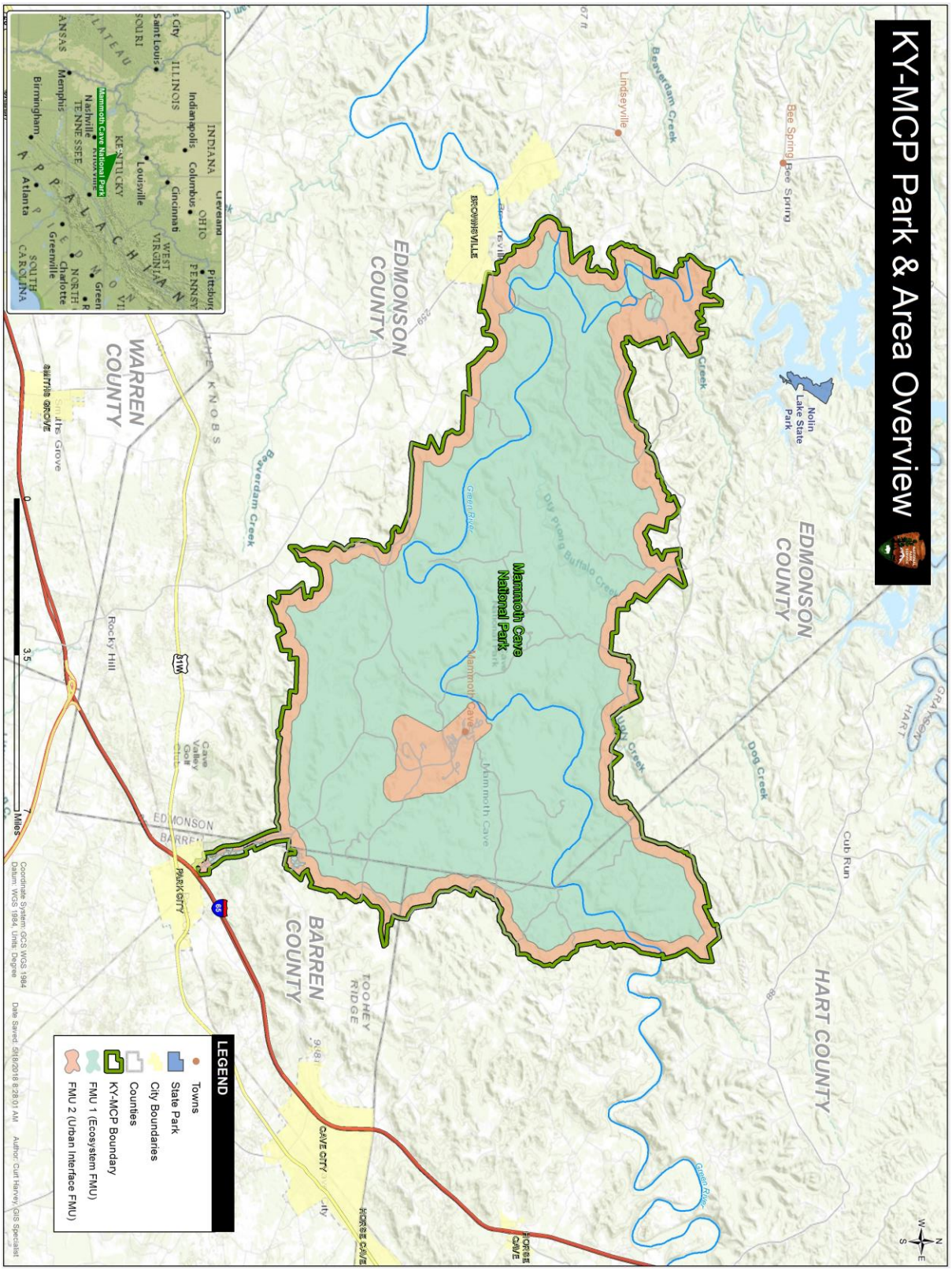
Figure 4: Alternative 2 – Mammoth Cave NP Fire Management Units



Comparison of Alternatives

Table 4: Comparison of alternatives with regard to key changes

Comparative Element	Alternative 1- *No Action*	Alternative 2 – *Preferred Alternative*
Fire Objectives Differences	Full suppression	Allows for fire management for multiple objectives, including resource benefits
Management of Wildfire Ignitions	No use of *Managed Fire for Multiple Objectives*, full suppression only	*Managed Fire for Multiple Objectives*, including resource benefits
Prescribed fire acres (per decade)	4,350 acres	Approximately 10,470 acres per decade
Manual Fuels Treatment Reduction Projects	100 acres per decade	Approximately 100 acres per decade
Mechanical Fuels Treatment Reduction	Not Applicable	Approximately 500 acres per decade
Estimate of Herbicide Use Herbicide use is by spot application to individual plants	Not Applicable	Approximately 1,500 acres per decade
Park Goal: Restore and maintain natural vegetation communities	Yes Prescribed fire would be allowed, but the average acres burned per year is not sufficient to restore new areas and continue maintenance burns on previously burned areas on a recommended rotation. This alternative provides the least amount of opportunity for restoration and maintenance of natural landscapes.	Yes This alternative utilizing mechanical/manual vegetation management techniques and herbicide treatment does allow managers to restore and maintain natural vegetation communities where deemed appropriate in the park. Opportunities to utilize prescribed fire to meet resource and management objectives are allowed This alternative provides the greatest opportunity and flexibility for restoring and maintaining natural landscapes.
Park Goal: Utilization of Prescribed Fire	Prescribed fire utilized throughout the park, but limited to broadcast burning.	Prescribed fire, including pile burning would be utilized where appropriate throughout NPS administered sites.

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Comparative Element	Alternative 1- *No Action*	Alternative 2 – *Preferred Alternative*
Project Need: Reduces hazardous fuel accumulations.	Minimal. Through the use of higher risk more restrictive broadcast burning. Manual fuel reduction would occur in and around developed areas throughout NPS administered sites and wildland urban areas. This alternative provides the least amount of opportunity for hazard fuel reduction activities due to the more restrictive operational guidelines managing the use of broadcast burning.	Yes. Mechanical/Manual fuel reduction would occur in and around developed areas throughout NPS administered sites and wildland urban areas. This alternative provides the most opportunity for effective hazard fuel reduction opportunities due to the use of mechanical and manual fuel reduction operations which are completed under less restrictions and can create piles of fuels that can be burned during safe times of the year.
Project Need: Protect human life and property both within and adjacent to the park.	Yes. All wildland fires – wildfire, would be suppressed throughout the park as soon as detected. This alternative has the least amount of hazard fuel reduction projects.	Yes. All wildland fires –wildfire, would be suppressed throughout the park when threatening life and property. Mechanical/Manual fuel reduction projects would be used to modify wildland fuel loadings reducing wildfire potential near developed areas and in areas with heavy fuel accumulations where deemed necessary throughout the park. Prescribed fire would be utilized to meet wildfire hazard reduction goals where appropriate, throughout the park. This alternative will treat the most acres.

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2.4 Alternatives Considered but Not Analyzed

The following alternatives were considered but not analyzed in this environmental assessment.

No Fire Management Action: The concept of an alternative geared toward truly no action was considered but rejected. It is neither possible nor consistent with any NPS guidance or policy to allow fires to burn without any form of management or response. Management and monitoring is required on all wildfires to protect human safety, natural and cultural resources.

Full Wildfire Suppression and No Prescribed Fire Program: Under a Full Wildfire Suppression alternative all ignitions would be suppressed, and no management ignited prescribed fires would be conducted. Full suppression does not necessarily mean that all Park fires would be small or have limited impacts. Some fires could burn with such intensity that suppression efforts could only attempt to lessen impacts until burning conditions changed enough to allow for effective suppression. A Full Wildfire Suppression and No Prescribed Fire Program does not achieve park goals or NPS policy objectives. NPS Director's Order 18 states: "Restore and Maintain Fire-adapted Ecosystems: Maintain and restore fire adapted ecosystems using appropriate tools and techniques in a manner that will provide sustainable, environmental and social benefits." For these reasons, the wildfire suppression and no prescribed fire alternative was rejected.

Mechanical Fuels Reduction and Full Suppression: An alternative emphasizing only mechanical fuels reduction and full suppression was considered and dropped from further analysis. Under this alternative the fire management program would treat fuel accumulations on approximately 250-500 acres of ice damaged forests and fire killed Virginia pines with a masticator mounted on heavy equipment. All wildfires would be suppressed at minimum acreage. Because it does not include prescribed fire, this alternative would not allow the park to meet management objectives; therefore it was not analyzed.

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3 Chapter 3: AFFECTED ENVIRONMENT and ENVIRONMENTAL CONSEQUENCES

This section analyzes both beneficial and adverse impacts that would result from implementing either alternative described above in Section 2. It is organized by resource and provides a comparison between alternatives based on the issues identified for detailed analysis. This document addresses the direct and indirect potential environmental impacts from all aspects of the No Action Alternative and the Preferred Alternative. At the conclusion of each resource discussion, applicable cumulative impacts are described and a brief discussion of the importance of impacts is provided.

For all environmental consequences analyses provided below, it is assumed that the mitigation measures and best management practices described in Section 2.4: *Mitigation Measures/Best Management Practices* 4 and new measures as they are discovered would be implemented under the Proposed Action, in accordance with the park's revised programmatic SFMP. These mitigation measures are intended to minimize adverse impacts to resources, while achieving the objectives of the programmatic SFMP.

3.1 Physical and Biological Resources Impact Topics Discussion and Analysis

3.1.1 Air Quality

Affected Environment

Air quality is important to park managers. Mammoth Cave National Park is a Class I Area under the Clean Air Act 1963 as amended in 1977. Class I areas have the strictest rules governing Particulate Matter (PM-10microns and 2.5 microns), Sulfur Dioxide (SO2) and Nitrogen Oxide (NO2) concentrations in the air.

Most visitors expect clean air and good visibility in parks. However, Mammoth Cave National Park, experiences relatively poor air quality, though air quality is improving. The park is downwind of many sources of air pollution, including power plants, urban areas, and industry in Kentucky and Tennessee. Pollutants emitted from these sources can harm the park's natural and scenic resources such as upland surface waters, plants, fish, bats, and visibility. (Mammoth Cave NP website, 2013)

Air quality in the park is impacted by smoke's fine particles, nitrogen oxides, sulfur oxides as well as ground level ozone, and airborne toxics such as mercury. The park currently operates air quality monitoring equipment that determine quantities of fine particles, haze, ozone, nitrogen, sulfur and mercury present in the park. The park conducts annual surveys of effects on ozone sensitive plants, measure amounts of nitrogen and sulfur deposition in the park and support research on the effects of mercury deposition. Haze monitoring is also an on-going task of the park. The park also works with federal, state and local industries, industry and public interest groups in developing strategies to reduce air pollution helping to protect and restore park resources.

Prior to all prescribed fires the park staff will notify the Kentucky Division of Air Quality. The notification will identify the location, size, and purpose of the prescribed burn, as well as distance to smoke sensitive areas. Prescribed burn plans will include mitigation measures

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(listed in Appendix 2: *Mitigation Measures*) and future effective mitigation measures as they come online to minimize impacts on public safety when winds have the potential to carry significant smoke that could impact traffic corridors, communities, and visitor safety.

3.1.2 Analysis of Alternatives and Impacts on Air Quality

3.1.2.1 Air Quality Impacts of Alternative 1 – No Action Alternative

Under the Alternative 1 fire management activities impacting air quality would be associated with fire suppression and prescribed fire.

3.1.2.1.1 Wildfires

Air quality is important to the park. Wildland fire smoke and dust generated from heavy equipment traffic on gravel and dirt roads and mop-up digging operations are the main sources of potential negative impacts to air quality. The park wants to protect staff and visitor's health from negative effects due to inhalation of smoke and dust; secondly there is a desire for the park to protect visibility of vistas in the park.

Particulate material and other compounds in smoke can enter people's lungs creating breathing problems. The amount of smoke a person inhales is determined by how close they are to the fire and how long they are in smoky conditions. During a wildland fire event the park restricts visitors and non-essential staff from entering the vicinity of the fire. This avoidance mitigation strategy as well as other general and air quality mitigation methods listed in Appendix 2 *Mitigation Measures/Best Management Practices* limits the amount of smoke visitors and non-fire staffs are subject to. Further limiting smoke impacts to people is the fact there are few wildfires and few proposed prescribed fire projects in the park.

Under Alternative 1 the amount of wildfire smoke is determined by how fast a wildfire can be suppressed. Wildfires in the park generally last a few hours to 4-5 days before they are suppressed. Few wildfires have occurred in the park; since 2003 there have been 11 wildfires burning 4.7 acres. Alternative 1 with a fire suppression strategy of full suppression of wildfires and keeping them to minimal acreage would in the short term have the least wildfire generated smoke. Due to the low number of wildfires, small acreages burned and the short duration of park wildfires it is believed that air quality impacts from wildfires would likely be short-term and localized.

Air pollutants and dust would be generated by use of gasoline-powered equipment used for wildfire suppression operations and can become a component of inhalants entering people's lungs. Gas powered equipment pollution would have similar effects as automobile exhaust on visitors entering the park. Implementation of listed mitigation measures to protect visitors; mainly avoidance of fire suppression areas would protect visitors from these emissions and therefore is not a major concern of park managers.

Dust is created by fire suppression operations (containment line construction and mop-up) and suppression equipment traffic on gravel and dirt roads could also directly impact air quality in areas where suppression activities are occurring. Dust directly impacts the areas of operations and does not spread much further because the transport mechanism is wind.

The park recognizes the creation of dust associated with fire suppression operations but with dust abatement mitigation measures such as watering gravel and dirt roadways being used by

heavy truck traffic, the low incidence of wildfires and the localized nature of the impacts this is considered a short-term localized impact. This is not considered a major problem for the park.

Wildfire smoke and wildfire suppression actions creating dust affect air quality and associated visibility in the park. The amount of smoke generated during a wildfire is difficult to determine, due to the unregulated nature of wildfire smoke. Wildfire smoke would affect visibility in two ways: first is the smoke in the vicinity of the fire which can be very heavy causing visibility problems in nearby travel corridors and secondly by forming haze which can reduce the natural visual range from about 110 miles to less than 1 mile until transported by winds to downwind areas, eventually dissipating from the air.

Wildfire smoke impacting travel corridors is mitigated by closing roads or providing pilot cars to lead non-fire vehicles through smoky areas. Due to the low incidence of wildfires and their short duration these mitigation measures would protect visitors from negative impacts of low visibility along travel corridors.

Wildfire smoke contributes to regional haze by mixing with other source pollutants inside and surrounding the park. Wildfire smoke is unregulated and does not contribute to non-attainment air quality determinations. Due to the uncontrollable nature of wildfire smoke the park under Alternative 1 would minimize any wildfire smoke coming from park lands by aggressively suppressing any wildfire in the park resulting in short-term park wildfire smoke additions to regional haze.

During and immediately following a wildfire, smoke, particulate matter, and dust emissions could impact visibility within the park and air quality standards may temporarily be exceeded within and adjacent to the burn area.

In summary the direct adverse effect of wildfire smoke pollutants on air quality, given the limited size and scale of wildfires and infrequency of activity, would be localized and last until the completion of suppression actions, generally a few hours to a few days and is not considered a major problem for the park.

3.1.2.1.2 Prescribed Fire

Prescribed fire projects are planned which means that fire managers have more control over how much smoke is produced and where the winds will transport smoke generated by the prescribed fire. Prescribed fire projects will directly affect air quality the same as wildfire smoke and suppression operations. Alternative 1 proposes prescribed burning a maximum of approximately 4,350 acres over 10 years. The number of actual burns could average 2-3 per year. Smoke from a prescribed fire could directly impact visibility on travel corridors, which is mitigated with the same methods as listed for wildfires.

The prescribed fire program is designed to minimize impacts to air quality by utilizing air quality mitigation measures and best management practices listed in Appendix 2. Prescribed fire smoke is regulated by the state smoke implementation plan and administered by the Kentucky Division of Forestry. The state layer of smoke regulation provides another layer of protection to air quality in and around the park. The state will be notified of all planned prescribed fire projects, and prior to ignition on the day of the burn.

All prescribed fire plans will include a weather prescription which includes minimum daytime requirements for smoke dispersion. Requirements currently require a minimum mixing height elevation and transport wind speed, or a minimum daytime dispersion index. Other prescription parameters may be used provided that they set specific, measurable atmospheric conditions that will facilitate smoke dispersion on the day of the burn.

Impacts to smoke-sensitive areas, such as private residences, would be minimized for prescribed fires by limiting the amount of acres burned at one time and timing ignitions early in the day to allow for combustion that is more complete during daytime conditions. If smoke emissions create unsafe conditions along roadways or other smoke sensitive areas, it may be necessary to terminate the prescribed fire.

The park's prescribed burn program follows the latest national smoke management guidance, the NWCG Smoke Management Guide for Prescribed Fire (Peterson et al. 2018). The guide provides wildland fire practitioners with a fundamental understanding of smoke management, including tools for managing smoke from wildland fires (Peterson et al. 2018).

In the presence of sunlight prescribed fire smoke can indirectly contribute to the development of ozone at ground level through the introduction of combustion-released nitrogen oxides that combine with other sources, both inside and outside the park. Burning under state approved burn days facilitates transport of smoke out of the park reducing the amount of nitrogen oxides available for ozone generation which mitigates this potential impact.

Dust generated from prescribed burn operations would have the same direct effects as wildfire operations.

3.1.2.1.3 Manual Fuels Reduction

Manual fuels reduction operations are mowing of vegetation, raking/blowing leaves and some cutting of debris on the ground with chainsaws. These operations are similar to other maintenance operations and are not considered important contributors to air quality concerns at the park.

Alternative 1 does not include mechanical fuels treatment projects.

Alternative 1 does not include herbicide treatments for fire management projects.

Air Quality: Alternative 1 Cumulative Effects

Cumulative impacts to air quality would occur if planned or unplanned ignitions occur on lands outside the park at the same time fire management activities occur on park lands. Coal-burning power plants are the major sources of pollutants to the atmosphere in and around the park. The duration of the cumulative impact would coincide with the duration of the concurrent fire events. Lack of control over atmospheric and drought conditions when unplanned wildland fires begin increase their potential to contribute emissions to the local airshed. These impacts would be local and regional, short and long term, and adverse. The cumulative effects of the No Action Alternative to air quality would be sporadic and temporary. The application of the NWCG Smoke Management Guide (Hardy et al. 2001) would reduce the intensity and duration of those contributions.

3.1.2.2 Air Quality Impacts of Alternative 2 – Preferred Alternative

Under Alternative 2 fire management activities impacting air quality would be associated with fire suppression, prescribed fire, mechanical/manual fuels reduction projects, and herbicide treatments.

3.1.2.2.1 Wildfires

Types of impacts would be similar as described for Alternative 1 for wildfire suppression responses and fire management activities. The major difference is that under Alternative 2 wildfires can be managed for multiple objectives. This means wildfires will be allowed to burn as long as they meet management defined limitations as specified in the Park's SFMP. Wildfires managed for other resources are monitored and if monitoring indicates the smoke from the wildfire will negatively impact defined smoke sensitive areas the fire is suppressed. The infrequency of wildfires in the park, historically 1 per year burning an average of 0.4 acres means that there will be minimal opportunities for negative direct impacts on air quality.

3.1.2.2.2 Prescribed Fire

Direct and indirect impacts of prescribed fire on air quality in Alternative 2 are the same as in Alternative 1. The difference is that Alternative 2 proposes an increased prescribed burn program, from 4,350 acres (Alternative 1) per decade up to approximately 10,570 acres per decade (10,470 acres prescribed burns and 100 acres of pile burns) under Alternative 2.

Although more acres overall will be burned, dust generated from prescribed burn operations would have essentially the same direct effects as discussed in Alternative 1.

3.1.2.2.3 Mechanical and Manual Fuels Reduction Project Operations

Use of large machinery in mechanical fuels reduction projects and small engines such as mowers chainsaws in manual fuel reduction would have the same effects as normal maintenance equipment: back hoes, dump trucks, chainsaws and weed whackers used in the park. The effects would be temporary and localized and have minimal impacts on air quality.

3.1.2.2.4 Herbicide Use

Targeted herbicide use could result in temporary herbicide mist in the air within the treatment area due to spray drift and volatilization (evaporation of liquid to gas). Implementing mitigation measures, such as lower nozzle pressure producing larger droplets reducing potential spray drift and the minimal use of herbicide treatments would reduce the potential for drift into non-target areas and the amount released into the air through volatilization. Airborne herbicide risks have been documented as insignificant in smoke, even when prescribed fires are applied immediately after herbicide application (McMahon and Bush 1991, Bush et al. 1998).

Air Quality: Alternative 2 Cumulative Effects

Cumulative impacts from past, present, and reasonably foreseeable future actions would be the same as described for Alternative 1. The addition of managed fire for multiple objectives has the potential to increase total emissions from a wildfire, but wildfires are infrequent at 1 per year and with air quality management restrictions in place concerning the parameters the fire would be allowed to burn under there will not be a significant cumulative impact to air quality.

Prescribed fire could temporarily impact air quality within, adjacent and downwind of the burn area from smoke and particulate emissions. Downwind impacts are mitigated through the state smoke management program guidelines, through utilization of state control of ignition time

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periods. The cumulative impacts on air quality would be negligible because air quality impacts would only last as long as the prescribed burn activities, generally one (1) day for the burn and up to five (5) days of smoldering as heavier fuels burn out.

Conclusion

Under both Alternative 1 and Alternative 2, short-term adverse impacts to local air quality primarily in the form of smoke, particulate matter, ozone and associated reduced visibility from prescribed burns and unplanned ignitions would occur. Impacts from unplanned ignitions would be short term, infrequent, and unpredictable. Unplanned ignitions have the potential to contribute more pollutants to the surrounding communities due to the lack of control over atmospheric conditions when unplanned wildland fires begin. Impacts from prescribed burns would be short term, lasting the duration of each prescribed fire. Under the Preferred Alternative, up to approximately 1,200 acres per year could undergo treatment by prescribed fire and mechanical/manual treatments. Given that this acreage would likely be treated over a series of prescribed burn events and the park's commitment to implement smoke management BMPs, impacts to air quality would short-term and minor, lasting only the duration of the prescribed burn, and given the relatively small areas that would be burned at any one time. The application of the NWCG Smoke Management Guide (Hardy et al. 2001) would reduce the intensity and duration of those contributions.

3.1.3 Vegetation Resources

Affected Environment

The Park contains more than 1,200 species of flowering plants, including 84 species of trees, many of which are dependent on wildland fire as a disturbance process for their preservation. Over a third of the park is dominated by oak-hickory forests and woodlands. Fire is a fundamental process in the development and maintenance of this important community type (Burton 2013).

The park is located in the transitional zone between historic open grasslands and drier oak-hickory forests to the west, and the more moist mixed mesophytic forests to the east. The park is likewise located transitionally between the sub-tropical climates to the south and the colder climates to the north. The result is a mixed mesophytic forest with many of the plant species found in the park at their northern, southern, eastern, or western limits of their natural range. Table 5 summarizes fire regimes for vegetation types in the park. Fire Regime Groups 1and II are fire prone or managed by fire and fire regime groups III and V are non-fire dependent. Following is a brief description of the types of vegetation communities present in the park:

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Table 5: Vegetation Habitat Type Typical Species Fire Regime Group (Olson and Noble 2005)

Vegetation	Habitat Type	Typical Species	Fire Regime Group	Relationship to Fire
1. Subxeric deciduous forest / savanna	Acid subxeric Calcareous subxeric	chestnut oak post oak chinkapin oak blackjack oak post oak	Group I Frequent, 0–35 years, surface and mixed severity	Historically Prone or Managed by Fire
2. Mesic upland deciduous	Acid Mesic Calcareous subxeric (thin beds)	white oak pignut hickory black oak	Group I Frequent, 0–35 years, surface and mixed severity	Historically Prone or Managed by Fire
3. Prairie/open area	Calcareous subxeric Acid mesic	native grasses and forbs mown grass	Group II Frequent, 0–35 years, stand replacement severity	Historically Prone or Managed by Fire
4/5.Mixed deciduous / coniferous Mixed coniferous / deciduous forest	Acid mesic Calcareous subxeric Alluvium	red maple tulip poplar dogwood sweetgum cedar/pine	Group III Infrequent, 35–100 years, surface and mixed severity	Non-fire Dependent
6. Coniferous forest	Acid xeric to mesic Calcareous xeric to subxeric	Virginia pine eastern red cedar	Group III Infrequent, 35–100 years, surface and mixed severity	Non-fire Dependent
7. Mesic hollow /floodplain deciduous forest	Calcareous mesic Acid mesic Alluvium	sugar maple beech box elder sycamore	Group V Rare, >200 years, stand replacement severity	Non-fire Dependent

Habitat type nomenclature follows the system of the Kentucky State Nature Preserves Commission (Evans 1991). "Acid" refers to noncarbonate bedrock, which results in acid soil, and "calcareous" refers to carbonate bedrock, which results in more alkaline soil. "Xeric" refers to dry areas, "mesic" to moist, and "alluvium" to river-lain sediments. In subxeric deciduous forest, chestnut oak and chinkapin oak sort very distinctly with sandstone and limestone substrates respectively, whereas blackjack and post oaks are less selective. With periodic fire, some forest stands may have been a more open woodland or savanna in the past.

Oak-Hickory Forest/Savanna - On broad uplands in the park separated by large karst valleys in areas north of the Green River and similar areas south of Green River, oak-hickory forest covers relatively large areas of acid mesic-subxeric and calcareous sub-xeric habitat types which have been minimally disturbed. North of the river, sandstone capped uplands with similar habitats supporting oak-hickory forest are divided by narrower drainage channels. It is

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possible that portions of these uplands were oak savanna prior to settlement, especially areas adjacent to southerly slopes where fuels are more frequently combustible. The goal for prescribed fire in oak-hickory forest is to reduce the invasion of fire intolerant species such as beech and maple.

Karst Valley Forest/Savanna/Prairie - Pre-settlement vegetation types in karst valleys south of Green River are unknown, and most of these large expanses of calcareous sub-xeric habitat were farmed prior to park establishment. The farmed areas have now become largely dominated by eastern red cedar and Virginia pine mixed with deciduous trees along the outer margins. Until these areas are studied, prescribed fire in karst valleys will be limited to maintenance of isolated prairie patches.

Mesic Slope and Floodplain Forests Moist ravines connected with the major river valleys support beech, maple, and tulip poplar in largely calcareous mesic habitats. On the floodplain alluvium, boxelder maple, sycamore, and infrequent river birch complement beech and maple. These habitats receive limited sunlight to dry fuels, and are watered by runoff in addition to their own catchment. Therefore the frequency of presettlement fire must have been very low except for prehistoric slash and burn agriculture that we have no desire to forcefully replicate. The same can be said for the supra-mesic habitats, and there are no plans to introduce fire in these areas. In some instances, portions of these very moist habitat types will be included within a prescribed fire unit to make the fire line safer and easier to manage, but this fire-intolerant vegetation will not be forced to burn.

Limestone Cedar-Oak Rock Outcrop Stands-In the driest limestone habitat types (calcareous xeric habitat), especially on south to west facing slopes, cedar-oak outcrop communities prevail. These are sites where eastern red cedar is not successional, and where the inherent dryness of the site is an important factor in limiting growth of deciduous trees other than drought tolerant species such as chinkapin oak and blue ash. Based upon field observation of scars, fire is a secondary factor in limiting the invasion of more mesic species. The source of fire ignitions is unknown. These scars could be from wildfires, pre-settlement burning or from agricultural practices prior to the creation of the park. However, given the vulnerability of eastern red cedar to fire, the intensity of fire must be typically low, and the ability of cedars to grow right out of exposed limestone benches puts some distance between them and the meager fuel available.

Ridgetop Pine-Oak Stands - Located on the dry edges of sandstone cliffs facing south to west, acid xeric habitats support nearly pure but narrow stands of Virginia pine and chestnut oak. Analogous to the cedar-oak glades, these sites are where Virginia pine is not successional. Droughty conditions are clearly a factor in the maintenance of these stands. Observations in the field have failed to detect fire scars on either pines or oaks, so until the role of fire is better understood, these stands will remain low on the list of priorities.

Prairie Ecosystem- Small remnants of prairie vegetation still exist in the park; with the Barrens area approximately 70 acres in size, other areas, such as part of the Wondering Woods tract, are smaller. We cannot be sure that any are actual remnants from pre-settlement times. Even so, these areas are rich in prairie grasses and forbs such as big bluestem, Indian grass, goldenrod, and tall coreopsis. They serve as refuges for species marginalized by conversion of

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former prairie on the sinkhole plain to agriculture, and by fire suppression within and beyond park boundaries. On the Barrens area, all prairie plants are from the seed bank and none were planted.

Contributing even more to the immense diversity of the flora is the wide variety of habitats supporting differing plant communities. There are dry upland flats and sandstone-capped ridges, limestone exposed slopes, ravines and karst valleys, broad alluvial bottoms along the Green River, gorge-like hemlock ravines, deep sinks with exposed otherwise subterranean streams, old-growth timber, successional growth forests, barrens and savannah habitats, and wetlands, including ponds, forest swamps, springs, seasonal wet woodlands, and cobble bars and banks along the Green River.

Past botanical surveys in the park have found 38 species listed by the state of Kentucky as Endangered, Threatened, or of Special Concern. A complete listing of Kentucky State Species of Concern found in the Park in Appendix 8. (Kentucky State Nature Preserves Commission 2015)

3.1.4 Analysis of Alternatives and Impacts on Vegetation Resources

3.1.4.1 Vegetation Resources: Impacts of Alternative 1 – No Action

3.1.4.1.1 Wildfires

Under Alternative 1, all wildfires would be suppressed using MIST with the park goal of keeping the fire to minimum size. Wildfires would be contained using existing natural barriers, roads, or trails further reducing the amount of vegetation removed. Emergency wildfire suppression actions could directly remove, cut, or trample vegetation due to fireline cutting operations. Depending on the height of the fuels there can be a cleared area inside the fire control line 1 ½ times the height of the fuels present. Visible firelines are present until the disturbed areas revegetate, which can take a minimum of one year. Tracked or wheeled equipment approved by the Superintendent or vehicles that carry fire personnel and equipment could directly trample or remove vegetation. It is important to park managers that direct impacted areas to vegetation caused by suppression operations and long term fire operations "scars" are kept as small as possible. Introduction of invasive or unwanted vegetative plants and seeds could occur from equipment used by fire crews during wildfire suppression efforts. Soil disturbance and bare areas from fireline construction could lead to increased opportunities for establishment and/or spread of invasive, non-native plant species. Mitigation measures would be implemented such as, cleaning equipment before and after use, firelines re-contoured and covered with cut vegetation debris, and utilizing targeted herbicide application and monitoring after fires to minimize potential impacts from invasive species. MIST fireline construction mitigation techniques will minimize effects on vegetation and other resources. In many areas leaf blowers could be used to remove leaf litter creating a barrier to fire spread with the use of water to wet the cleared area. Many of the areas disturbed during suppression operations will revegetate within a growing season.

Based on the use of natural fire barriers, mitigation techniques, and on the small number and size of wildfires that burn at the park (11 fires burning a total of five acres over the past 10 years), wildfire suppression operations are expected to have minimal short and long-term effects on vegetation..

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3.1.4.1.2 Prescribed Fire

Operational impacts of prescribed fire on vegetation are the same as for wildfire suppression operations. An important change is that prescribed fires are planned. Fire managers with the assistance of park staff dictate how, where and when a prescribed fire is completed. Prescribed fire projects are located in defined areas which were developed by park staff to more effectively utilize natural and man-made barriers for fire control lines where possible. Utilization of these areas reduces the amount of bare ground available for invasive and non-native plant species to colonize. Prescribed fires are mostly carried out in vegetation communities that are fire dependent thereby facilitating native species propagation, further reducing invasive and non-native species opportunities. There will be no prescribed fires in the Big Woods area of the park to avoid further damage. Prescribed fires will not be ignited in successional stands of old fields, however fire will be allowed to spread from adjacent areas. Forest in old fields need time to go through ecological succession to become dominated by mature fire tolerant trees such as oak and hickory. Protection of these areas is a high priority for the park.

Under Alternative 1, hazard fuel loadings in and around wildland urban interface areas and park infra-structure would continue to accumulate, which would increase the potential for larger more intense wildfires near these areas. Wildfires under these conditions could remove large tracts of vegetation and soil organic matter (duff/litter), altering soil resources (e.g., kill rhizomes and mycorrhizae), which could lead to changes in vegetation species composition, structure, and diversity. Park assessment of the proposed prescribed program for Alternative 1 indicate that the 4,350 acres per decade of burning is not large enough to maintain and enhance fire dependent plant communities, therefore Alternative 1 provides the minimal amount of burning for ecosystem management. An indirect effect over time, fire-dependent vegetation communities such as oak-hickory forests as well as prairie sites could continue to change in species composition and diversity as well as decline in the overall health and vigor of the forest stands.

3.1.4.1.3 Manual Fuels Reduction Treatments

Mowing of grasses and brush species, raking and blowing dry leaves and some cutting of debris on the ground around park infra-structure is not likely to impact vegetative species any more than already approved landscape maintenance operations.

Alternative 1 does not propose any mechanical fuels reduction treatments or any herbicide treatments associated with fire management operations.

Vegetation Resources: Alternative 1 Cumulative Effects

Activities that could contribute to cumulative impacts to vegetation resources include fire management activities within the park and on adjacent lands which removes native vegetation and could create open areas that allow invasive plant species to germinate becoming sources of unwanted vegetation inside and outside the park. Invasive species seeds deposited by falling off vehicles coming into the park, park management activities, agricultural practices, and private landscaping near the park boundary can become invasive seed sources. Timber harvesting on adjacent private lands can create open areas that can become source areas for invasive species that could spread into the park. Under Alternative 1, the incremental impacts to vegetation resources within the park would continue through implementation of a prescribed fire program covering up to 4,350 acres over 10 years. Alternative 1 in combination with the past, present,

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and foreseeable future actions could contribute to adverse cumulative impacts on vegetation resources because of the increased potential for intense wildfires, which could remove larger tracts of non-fire dependent vegetation. Alternative 1 with a minimal prescribed fire program that does not propose to burn enough of the acreage covered by fire-dependent vegetation will over time cause a reduction of these species. Over time, the lack of fire at the right time and place could lead to the disappearance of some fire adapted vegetation on the landscape. Fire dependent vegetation provides long-term benefits through improved ecosystem functioning, restoration to historic vegetative conditions, and improved resilience to wildfire across a broader area. Alternative 1 would contribute to cumulative short-term adverse and long-term beneficial impacts to vegetation.

Cumulative impacts to vegetation could occur as a result of the Alternative 1 and other actions (e.g., development or prescribed burns conducted by local government and private entities, trail development in the park, and trail and road maintenance in the park). The cumulative effects of removing individual plants is not expected to rise to population-level effects.

3.1.4.2 Vegetation Resources: Impacts of Alternative 2 –Preferred Alternative

3.1.4.2.1 Wildfires

The impacts of wildfire actions on vegetation under Alternative 2 are similar to Alternative 1. A major difference is that Alternative 2 allows managed fire for multiple objectives. The effect is that wildfires would become larger as long as they burn within pre-determined management constraints. Constraints would include where the fire is allowed to burn, such as no burning in areas of non-fire–dependent species and allowance of continued burning in areas of fire-dependent species. With historic wildfire incidents of 1 fire per year it is not expected that a modest increase in acres will have more than minimal impacts on vegetation in the park.

3.1.4.2.2 Prescribed Fire

Alternative 2 proposes to implement prescribed fires that would emulate a natural fire regime that directly benefits fire-dependent forest and prairie communities. Prescribed burning will directly kill some plants within the burned area. Because it is important to the park that the prescribed fire program focus on fire-dependent plant communities there will be a direct benefit to those plants by reducing competition from non-fire-adapted plants. Prescribed fires would indirectly benefit fire fire-dependent native vegetation communities over the long term by rejuvenating the soils with a temporary influx of nutrients and minerals, which stimulates seed production (Neary et al. 2005). Prescribed fire directly benefits fire-dependent vegetation communities by reducing encroaching mesophytic trees such as beech and maple, and promoting understory growth of grasses and forbs. The grasses and forbs would regenerate within the growing season. Prescribed fires are typically low intensity, surface fires that help to maintain and enhance the survival of fire-dependent vegetation communities and seedbeds. Beneficial impacts to fire-dependent vegetation communities would be long term due to reducing non-native plant species and enhancing the diversity, structure, composition, and integrity of fire-dependent vegetation communities, such as mixed oak and prairie communities by increasing seed production. Overtime, the use of prescribed fire would be expected to decrease the potential for intense wildfires by reducing heavy fuel loads. As in Alternative 1, Alternative 2 proposes no prescribed fire ignition in successional stands in old fields or the Big Woods section of the park. Protection of these areas is a park priority.

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3.1.4.2.3 Mechanical/Manual Treatments

The major difference in Alternative 2 is that the park will actively manage hazard fuels in areas collaboratively determined by park staff and fire management specialists, thereby reducing potential for larger more intense wildfires and reducing opportunities for colonization of invasive and non-native plants. This would help restore native forests and prairies that benefit from less intense fires. Alternative 2 proposes the use of mechanical/manual treatments for approximately 600 acres (500 acres mechanical with an additional 100 acres of manual treatments) over 10 years.

The use of wheeled/tracked equipment, such as masticators could possibly result in damage to non-targeted trees or spread invasive plant species. Park staff would implement mitigation measures to reduce potential impacts to non-target trees. Mechanical/manual treatments would directly benefit native vegetation by helping to perpetuate a more open forest structure where appropriate, which would increase sunlight and moisture availability for growth and germination of ground cover, grasses and forbs within the growing season. Mechanical/manual treatments would be used in combination with the other fuel/vegetation management tools to help accomplish forest and prairie restoration.

3.1.4.2.4 Herbicide Use

Alternative 2 proposes approximately 1,500 acres of targeted herbicide applications on land associated with fire management operations. Spot herbicide application focused on individual unwanted plants or groups of plants would be used. Limited herbicide use and targeted application to specific basal or foliar plant areas would minimize chances of over spraying and impacting non-target plants. There will be minimal direct negative impacts to non-targeted plants and potential indirect positive benefits as invasive species are removed and native plants become established in the treated areas over time.

Vegetation Resources: Alternative 2 Cumulative Effects

Cumulative impacts from past, present and reasonably foreseeable future actions would be similar as described for Alternative 1. Alternative 2 does allow for managed fire for multiple objectives in FMU 1. This means there will be a potential increase in average fire size. Wildfire incidence should still remain low, currently 1 fire per year, and with management restrictions in place on acceptable post-burn outcomes the expected increase in wildfire burned acreage should be minimal. Alternative 2 would temporarily impact larger areas of vegetation from the use of prescribed fire, approximately 10,570 acres versus Alternative 1's 4,350 acres per decade and Alternative 2's proposed mechanical/manual treatments of approximately 600 acres per decade (500 acres machine fuel reduction and 100 acres manual treatment projects) versus 0.00 acres mechanical/manual treatments proposed in Alternative 1. The increased impacts would continue until growth of native vegetation occurred. However, over time Alternative 2 would also contribute to beneficial cumulative impacts to vegetation resources by reducing hazard fuel loads, thus reducing the potential for larger intense wildfires and restoring native vegetation with the return of a natural fire regime. Implementation of Alternative 2, in conjunction with past, present, and reasonably foreseeable future actions, would be expected to improve vegetation conditions and contribute to beneficial cumulative impacts. Fire dependent forest and prairie would be expected to improve over current conditions, providing long-term benefits through enhanced ecosystem functioning, restoration to historic vegetative conditions, and improved resilience to wildfire across a broader area.

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Conclusion
Effects to vegetation as a result of prescribed fire, and wildfire suppression would be the same under both alternatives. Under the Preferred Alternative, the impact of managing unplanned ignitions on vegetation would be adverse in the short term and beneficial in the long term; however, the extent of these effects are somewhat unpredictable. Under each alternative, adverse impacts are unlikely to rise to population-level impacts except at a localized level. The use of prescribed fire and managed wildland fire would have substantial long-term beneficial effects to fire dependent vegetation.

3.1.5 Wildlife Resources

Affected Environment
Mammoth Cave NP contains a wide variety of wildlife species some living in very specialized ecosystems. Mammals, fish, amphibians, crustaceans, reptiles and birds utilize the park, either as a permanent or transitory home.

Mammals: There are 45 species of mammals that utilize the park. Common mammals that inhabit the park are: bats, bobcats, coyotes, foxes, muskrats, gray squirrels, flying squirrels, rabbits, raccoons, skunks, beaver, mink, weasels, groundhogs, chipmunks, moles, voles, mice, and woodrats.

Fish: Perhaps the most unusual fish in the park are those cave-adapted species, the Northern Cavefish, and the Southern Cavefish, known generally as eyeless fish. They have adapted to lightless, low-energy environments by ceasing to grow eye structures and unnecessary skin pigments. Surface fish include most game fish found in the eastern United States, including bluegill, crappie, largemouth bass, muskellunge, drum/white perch, striped bass, gar, and catfish, among others.

Amphibians: The park is home to a variety of salamanders, toads, and frogs. Currently there have been identified 14 kinds of frogs and toads, 16 kinds of salamanders, 8 types of lizards, 22 types of snakes and 9 types of turtles.
Among the species here are:
Salamanders: Mudpuppy, Hellbender, Red spotted newt, Jefferson salamander, Spotted salamander, Marbled salamander, Tiger salamander, Zigzag salamander, Slimy salamander, Eastern mud salamander, Northern red salamander, Northern two-lined salamander, Long-tailed salamander, Cave salamander, Northern dusky salamander, Small-mouthed salamander
Toads: Eastern spadefoot toad, American toad, Fowler's toad
Frogs: Southern cricket frog, Mountain chorus frog, Spring peeper, Gray treefrog, Bullfrog, Green frog, Pickerel frog, Leopard frog, Wood frog, Eastern narrow-mouthed toad
Lizards: Fence lizard, Slender glass lizard, Six-lined racerunner, Ground skink, Coal lizard, Five-lined skink, Broad-headed skink.
Turtles: Stinkpot, Snapping turtle, Eastern box turtle, Map turtle, Slider, Red eared turtle, Smooth softshell turtle, Eastern spiny softshell.
Snakes: Worm snake, Northern ringneck snake, Hognose snake, Rough green snake, Northern black racer, Gray rat snake, Northern pine snake, Prairie king snake, Scarlet king snake, Black king snake, Eastern milk snake, Scarlet snake, Northern water snake, Northern brown snake, Red-bellied snake, Eastern garter snake, Butler's garter snake, Eastern ribbon snake, Southeastern crowned snake, Northern copperhead, Timber rattlesnake.

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Crustaceans: Troglobites found only in base level streams include the endangered Kentucky Cave Shrimp. The more adaptable cave crayfish occupies habitats ranging from base level to tiny streams, and can travel out of water if necessary. The troglophilic or partially cave adapted amphipod, the crayfish, the sculpin, and the springfish often occur in organically rich situations. Kentucky cave shrimp spend their entire lifetime in the cave. They thrive in an environment of total darkness, high humidity, and at a constant temperature of 54 degrees F. The entire known population of the Kentucky Cave Shrimp lives in or near Mammoth Cave National Park. Blind and semitransparent, these tiny crustaceans feed on bacteria, protozoa and other minute organisms that live on organic matter that wash into cave streams. The Kentucky Cave Shrimp, like other aquatic cave life, is vulnerable to degradation of water quality in its habitat. Contamination of groundwater by siltation and chemicals from agricultural land, inadequate sewage treatment, oil and gas development, and toxic spills could extinguish the species

Birds: MACA provides home and transitory range for over 200 species of birds, including grebes, herons, geese, ducks, vultures, hawks, bald eagles, quail, wild turkey, sandpipers, doves, hummingbirds, kingfishers, whip-poor-wills, owls, flycatchers, crows, blue jays, chickadees, titmice, nuthatches, wrens, thrushes, catbirds, starlings, vireos, wood warblers, tanagers, cardinals, sparrows, blackbirds, and finches. A wide variety of birds use the park seasonally in transition to/from other areas.

3.1.6 Analysis of Alternatives and Impacts on Wildlife Resources

3.1.6.1 Wildlife Resources: Impacts of Alternative 1 – No Action

3.1.6.1.1 Wildfires

Wildlife communities under Alternative 1 would be expected to remain as they currently exist. However, an intense wildfire could alter the current vegetation in ways that would locally alter wildlife communities. Post-fire wildlife communities would initially be limited to those that could colonize recently burned areas and would slowly shift to early successional communities.

The degree of impacts from wildfires on wildlife depends on the time of year, fire behavior, fire size, location, fuel composition, soil moisture, and species mobility. Direct impacts from wildfire suppression operations would temporarily increase disturbance to wildlife within and near the burned area due to noise from human presence and equipment, smoke, fire itself, and vegetation removal. Temporary loss of habitat and displacement may occur for individuals within the burned area until revegetation occurs. Direct mortality to small and less mobile wildlife species, such as turtles, snakes, and small mammals, may also occur from wildfires and associated operations, while larger wildlife species may not always be able to move out of the fire path in time, becoming disoriented and dying in the wildfire. Although there are potential impacts Park history indicates that wildfires in recent history (2003 to present) have been less than 0.5 acres in size with an average of one fire per year, which means habitat loss due to wildfires is not high for the park and mortality of general species is not high for their populations. Therefore, negative impacts to wildlife from wildfire are expected to be short-term and minor.

3.1.6.1.2 Prescribed Fire

Alternative 1 also includes up to 4,350 acres of prescribed burning per decade. Prescribed fire operations are the same as you would see on a wildfire. The major difference is that a prescribed fire generally is a cooler burn, designed to meet a management objective and the

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burn is pre-planned with mitigation measures for wildlife species incorporated into the prescribed fire plan. Common mitigation measures are timing of the burn outside of nesting times for birds, higher soil moisture and vegetation moisture to limit fire intensities and spread rates making it easier for mobile species to exit burned areas and others listed in Appendix 2 *Mitigation Measures and Best Management Practices.*

Prescribed fire and associated operations as with wildfire can directly kill wildlife as described under wildfires. Prescribed fire indirectly benefits individual fire-dependent wildlife species and their habitat by introducing fire back into fire-dependent vegetation types and creating a more historic and natural vegetation pattern across the park. Prescribed fires would provide more nutrients to the soils in the short-term, which would increase new plant growth, increase the amount of ground and grass species available and the nutritional quality of this forage indirectly benefitting wildlife species. Burned areas generally green up earlier than non-burned areas, thus providing earlier grazing (Redmon and Bidwell 2003). The effects of treatments on forest understory composition and growth vary. Overall, the use of fire and other tools to recreate historic forest/prairie conditions will be beneficial for wildlife because it helps restore a mosaic of ecosystem types that can benefit multiple species (Van Lear and Harlow 2000).

Prescribed fires could directly negatively impact nesting resident and migratory birds if conducted during the breeding season (generally between March–August) through mortality of fledglings that are unable to flee or avoid smoke or fire. To mitigate potential impacts, prescribed fire will be implemented outside the breeding season. Effects on breeding success would vary by species and is difficult to predict as bird abundance and species richness often do not change or increase several years following a fire; however, species dependent on dense shrubs typically decline (Zebehazy et al. 2004, Greenburg et al. 2007) and species preferring more open areas could increase. Some forest-nesting birds could become more susceptible to nest parasitism by brown-headed cowbirds due to the opening of the understory and increased open areas. Edge habitat, which could increase cowbird access to interior forest birds, would not change as existing human-made corridors and natural barriers would be used for firelines when possible. While there may be short-term, localized negative impacts to species in the vicinity of prescribed burn activities, the long-term impacts are expected to be beneficial as the vegetation communities upon which these species depend are restored to a more natural, fire-resilient condition containing a mosaic of habitat types.

3.1.6.1.3 Manual fuels Reduction Treatments

Mowing of grasses, blowing/raking leaves and using chainsaws to cut debris is not likely to have any more impacts than currently approved landscape maintenance operations.

Wildlife Resources: Alternative 1 Cumulative Effects

Past, current and reasonably foreseeable actions that impact wildlife include ongoing development in and around the park, management activities within the park, agricultural activities, traffic along roads, and wildland fires (wildfire and prescribed fire) on adjacent lands and in the park. Birds, bats, and large mammals, are capable of escaping wildfires and prescribed fire treatments and could occupy adjacent habitat during disturbance or until habitat is restored. Adverse cumulative impacts to wildlife could occur to less mobile wildlife species (juvenile or nestling birds, small mammals, amphibians, and reptiles) through direct injury or mortality from wildfires, prescribed fires and fire management activities. Alternative 1 could positively affect cumulative effects to fire dependent wildlife as the park utilizes prescribed fire

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to enhance fire-dependent vegetation communities. Alternative 1 with a smaller prescribed burn program could contribute to adverse cumulative impacts due to displacement and habitat alteration from larger more intense wildfires in areas of the park where fuels are allowed to accumulate unnaturally.

3.1.6.2 Wildlife Resources: Impacts of Alternative 2 – Preferred Alternative

3.1.6.2.1 Wildfires

Under Alternative 2 impacts to wildlife and their habitat would be similar as described under Alternative 1 for wildfire suppression. Unlike Alternative 1, Alternative 2 does use the management option of managed fire for multiple objectives. Therefore the park has the potential to have wildfires of larger size, but minimally so as the historic wildfire incidence for the park is one fire per year. Management control on acceptable burn and post-burn results will not allow for a large fire so direct negative impacts on wildlife are minimal. The use of additional fuel/vegetation management tools would increase the success rate of restoring fire as an ecological process, thus increasing the prevalence and vigor of fire-dependent vegetation indirectly benefitting associated native wildlife species present in the park.

3.1.6.2.2 Prescribed Fire

Alternative 2 proposes increasing prescribed fire acreage up to approximately 12,000 acres per decade (includes slash pile burning of 100 acres per decade). Prescribed fire in Alternative 2 has similar impacts as discussed in Alternative 1, though the greater number of acres burned under Alternative 2 will result in a larger extent of restored fire-dependent vegetation and resulting diverse structure and patchy mosaic including open areas that will promote wildlife.

While there may be short-term, localized negative impacts to species in the vicinity of prescribed burn activities, the long-term impacts are expected to be beneficial as the vegetation communities upon which species depend are restored to a more natural, fire-resilient condition containing a mosaic of habitat types. Wildlife species need a patchy mosaic habitat that is achieved through prescribed fire altering vegetation structure and composition for breeding and foraging. Wildlife diversity would increase over time through the enhancement of foraging and habitat availability.

3.1.6.2.3 Mechanical and Manual Fuels Reduction

By using mechanical and manual treatments near wildland urban interface areas and park infra-structure on approximately 600 acres per decade (combined machine projects and manual handpile projects), there will be a reduction in hazardous fuels to create and maintain defensible space and fuel breaks. This would also result in lower intensity ground fires, further protecting and maintaining native wildlife species and their habitat. Temporary displacement or disturbance to wildlife species within and near the treatment areas would occur during equipment use and field crew's operational periods. Wildlife would quickly re-colonize the area once the field crews left and therefore the impacts are not consequential. These projects are planned with park resource staff and will implement mitigation and best management practices listed in Appendix 2 as well as new mitigation measures as they become known. Negative effects on wildlife due to mechanical/manual fuels reduction operations are expected to be minimal, and the long-term benefits to species through habitat improvements are expected to be beneficial.

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3.1.6.2.4 Herbicide Use

Targeted herbicide application as a follow up treatment to control invasive species plants on fire management operational sites, such as foliar application to specific basal or foliar plant areas, would minimize chances for overspray and applying to non-target plants. Thus, mitigation measures, limited use, low-volume application of herbicide to specific basal or foliar plant areas, and following all labels would minimize chances for overspray and impacting non-target plants, benefiting wildlife species that utilize native plants,. In addition, herbicides commonly used for vegetation management have been designed to target biochemical processes unique to plants and have low levels of direct toxicity or risk to wildlife and fish when used in accordance with label specifications (Tatum 2004). Herbicides commonly used for vegetation management also degrade quickly upon entering the environment and are neither persistent nor bioaccumulate (Tatum 2004).

Wildlife Resources: Alternative 2 Cumulative Effects

The past, present, and reasonably foreseeable future actions would be similar to those described for Alternative 1. Alternative 2 would temporarily displace or kill more individual wildlife species due to the potential of managed fire for multiple objectives creating slightly larger wildfires and the expanded prescribed fire program causing more negative short-term impacts to wildlife, plus increased noise and human presence associated with expanded fire management operations, all contributing to adverse short-term cumulative impacts. However, Alternative 2 would also contribute to beneficial cumulative impacts to wildlife species dependent upon fire adapted species due to improved habitat quantity, quality and restored forest/prairie structure and composition due to a return towards a more natural fire regime and associated natural vegetation spatial arrangement.

Conclusion

Both alternatives could result in short-term adverse impacts to wildlife during fire suppression activities. Suppression activities related to unplanned ignitions would last the duration of the wildfire event but most wildlife species would be able to escape the area and utilize adjacent habitat.

Impacts to wildlife from prescribed fires would include wildlife mortality and displacement due to habitat loss. Less severe prescribed fires would result in mortality and displacement of a few localized individuals or groups of animals and would not jeopardize population trends. Thus adverse effects would be short term.

Use of wildfire for multiple objectives could result in the temporary displacement of wildlife or individual mortality of wildlife species. Wildland fires would have an immediate effect on wildlife and wildlife habitats by removing plant material, exposing soils, stimulating growth of some plants, and killing or reducing the vigor of some plants. The amount of habitat removed may depend on the following fire characteristics: size, severity, patchiness, and time of year. The loss of habitat would have an indirect, short-term minor effect by displacing wildlife over a relatively small area and for a short duration. While there may be short-term, localized negative impacts to species in the vicinity of wildfire activities, the long-term impacts are expected to be beneficial as the vegetation communities upon which species depend are restored to a more natural, fire-resilient condition containing a mosaic of habitat types. Birds, bats (in certain life history stages), and adult mammals are capable of escaping impact sources and can occupy adjacent habitat during disturbance and until habitat is restored. However,

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cumulative impacts to wildlife could occur under the Alternative 1. This could occur if mechanical treatments, wildfire, or prescribed burns occur simultaneous to development or planned/unplanned ignitions by landowners or agencies in adjacent areas, trail development in the park, and trail and road maintenance in the park. Such circumstances could compound the effects of temporary displacement on wildlife species by rendering habitats to which disturbed wildlife otherwise could escape also temporarily unsuitable. This could result in additional expenditure of energy and increased breeding and foraging competition. However, surviving individuals would be expected to repopulate disturbed areas over time. Species in less mobile life stages (juvenile or nestling), and less mobile species (small mammals, amphibians, and reptiles) could be cumulatively impacted by mechanical treatment and/or fire management through direct injury or mortality if they are experiencing similar effects from simultaneous activities (i.e., those noted above).

Under Alternative 2 – Preferred Alternative, there would be adverse impacts to some species during mechanical/manual treatments as a result of temporary human disturbance, direct mortality from crushing and trampling, and loss of forage and cover. However, such impacts would be short term, limited to the duration of treatment activity and are not likely to be substantial or rise to population-level effects.

Overall, fire management activities are expected to have a long-term beneficial effect on wildlife by maintaining or restoring a variety of habitat types. Prescribed fires carried out by the park would avoid sensitive resources through the use of MIST outlined in Appendix 5, thereby not contributing to adverse cumulative effects to such resources. Prescribed fire may contribute beneficially to habitat quality of all wildlife, including listed bat species, within and surrounding the park.

3.1.7 Species of Special Concern.

Affected Environment

Under Section 7 of the ESA of 1973, as amended, any action likely to adversely affect a species classified as federally protected is subject to review by the USFWS. At the park, 34 species of plants and animals are listed by the USFWS as endangered, threatened or candidates for listing. Appendix 9. There are 80 species listed as being of management concern for the Commonwealth of Kentucky (Appendix 4). The mitigation measures identified in Appendix 2 will help mitigate potential negative impacts to species of special concern.

Of the current federally threatened and/ or endangered species that reside in the park, three species are more likely to be directly impacted by the fire management program. They are the Indiana Bat, the Gray Bat, and Northern Long-Eared Bats. No longer federally listed, but still of concern is the Bald Eagle which is protected under the Bald and Golden Eagle Protection Act and Migratory Bird Treaty Act. Other species, including mussels (listed) and the Kentucky Cave Shrimp, may experience indirect effects from fire management activities, primarily related to water quality. Fire management operations will have minimal effects on water quality and therefore species of special concern that inhabit waterways, are unlikely to be affected by fire management operations, and the cave beetles, which exist in the cave environment will unlikely be affected by fire management operations due to burning restrictions on smoke entering cave environments.

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Impacts Common to All Alternatives

The northern long-eared bat and Indiana bat roost during the summer maternity season under exfoliating bark and in cavities of trees or snags (Johnson et al. 2009, Silvis et al. 2015). Mechanical, manual treatments and wildfire suppression activities could remove suitable roost trees for northern long-eared or Indiana bats. To avoid impacts to roosting bats during the maternity season, trees would be removed via mechanical and manual treatment from November 15 through March 31. If trees must be removed outside these dates, an emergence count would be completed prior to tree removal to ensure bats are not occupying trees marked for removal. If bats are using the trees, tree cutting would not occur until bats had left the roosting tree(s) and it is determined there are additional suitable roosting trees in the area available for bats to use. These areas would be monitored to ensure human disturbance is minimized. These measures would avoid adverse impacts to bats and their habitat as a result of mechanical treatments.

In untreated forest stands, hazard fuels would likely continue to accumulate, increasing the potential for localized, severe wildfires. Numerous potential effects to Indiana, gray and northern long-eared bats could occur as a result of wildfire. Wildfire may affect bats directly via heat and smoke that could potentially drift into rocky cliff roost sites or disrupting roosting and indirectly by modifying habitat, but these effects are largely unknown and likely vary by season and roost guild (Perry 2012). Studies suggest fire generally has beneficial effects on bat habitat by creating snags, reducing understory and midstory vegetation, opening forests, and possibly by increasing insect prey abundance (Perry 2012). The degree and extent of effects would depend largely on the season in which fire occurs and what the species are doing during that time. Specific mitigation measures have been developed for northern long-eared bats, gray bats and Indiana bats to minimize adverse impacts (USFWS 2016) (See Appendix 2).

American Bald Eagle

Bald eagles continue to be a species of special concern in the park. As stated in the USFWS's 2007 National Bald Eagle Management Guidelines,

"…prescribed burning close to the nest tree, should be undertaken outside the breeding season.……If it is determined that a burn during the breeding season would be beneficial, then, to ensure that no take or disturbance will occur, these activities should be conducted only when neither adult eagles nor young are present at the nest tree (i.e., at the beginning of, or end of, the breeding season, either before the particular nest is active or after the young have fledged from that nest)."

Two bald eagle nests have been located within the parks boundaries, along the banks of the Green River. These nests would only be impacted from direct fire, and smoke settling over the nests if the conditions were optimal. For controlled burning to occur specific prescriptions must be met before ignition of the fire is begun.

Direct fire impacts would only occur if the flood plain leading to the nests were very dry from the lack of rain. These conditions would not occur during a planned prescribed burn, due to the prescription for burning being greatly exceeded, and fire ignition would not occur.

Smoke impacts from fire may occur during an inversion along the Green River. Planning and mitigation measures are identified to minimize smoke impact in Appendix 2.

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In the event of wildfire during extreme weather conditions both nests have been global positioning systems (GPS) located and the burn hazard can be remediated quickly, eliminating the possible destruction of the nest, and potentially the birds.

At this time the burn window at the park is generally November 16 through April 30, primarily due to bat roosting habits vegetation green-up. During some of the parks' past prescribed burns in late April the percentage of green-up was much too high to reach a thorough and successful burn. Thus, along with setting a burn limit on April 30, there should also be a limit of percentage of green-up at which ignition of the prescribed burn does not occur. This date will vary from year to year, thus green-up must be checked and confirmed prior to the actual expected ignition of the prescribed burn.

3.1.8 Analysis of Alternatives and Impacts on Special Status Species

3.1.8.1 Special Status Species Impact Analysis: Alternative 1 – No Action

Under this alternative the current fire management program will continue. Due to the smaller prescribed burn program changes to vegetation will continue to move away from naturally occurring patterns and species composition indirectly affecting the species of concern present. The accumulation of fuels will allow for larger more intense fires with direct negative effects through mortality and displacement. The degree of impact is directly related to the species tolerance to fire initially and ultimately determined by the size of the fire, the duration and intensity of the fire and the season in which the fire occurs followed by the species ability to repopulate the burned area.

3.1.8.1.1 Wildfires

Fire, wildfire or prescribed fire, can harm or kill species exposed to flames, high heat or thick smoke. Species that have adapted to fire may benefit from the effects of fire, while species not fire adapted may be killed or displaced. Displaced species generally return to the burned area when new plant growth appears during the growing season. Wildfires are limited, historically 1 per year, and they do not get very large, averaging 0.5 acres. The park goal to "Promote in undeveloped lands the re-establishment of natural conditions and processes in areas previously disturbed by human uses" will benefit native species in the long run.

It is important to the park that special status species are properly managed in the park. Under Alternative 1 the park would suppress all wildfires utilizing MIST tactics and resource advisors would be available to aid in planning for special status species (federal or state) and consultation duties with the appropriate agencies.

Wildfire suppression tactics such as construction of fire lines, use of portable pumps, fire engines on roadways, and noise from human presence and fire equipment could directly displace or stress special status species within and near areas of operations temporarily. The length of time would be determined by the duration of the fire suppression effort, generally 1 to 5 days. With an average of 1 fire per year approximately 0.5 acres in size negative impacts are not significant. The park routinely consults with USFWS when park operations, including fire management, occur in the vicinity of known species of concern.

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3.1.8.1.2 Prescribed Fire

Alternative 1 proposes up to 4,350 acres of prescribed fire per decade. Prescribed fire and associated operations could have the same effects on special status species as wildfire operations. Impacts to bats and bald eagles from prescribed fires can include mortality and displacement due to habitat loss. Less severe prescribed fires could result in mortality and displacement of a few localized individuals or groups of animals or plants and would not jeopardize population trends making any adverse effects short term.

Management ignited prescribed fires are planned allowing Park staff to schedule prescribed fire management actions at the most effective/least disruptive time to minimize impacts to animal species, for optimizing vegetation growth periods or modify burn timing to be most effective in controlling exotic/invasive species. Alternative 1 proposes prescribed burning in fire-dependent communities in the Park. The planned prescribed fire areas were intentionally kept small to limit the scale of damage to park vegetation in case of unintended consequences.

3.1.8.1.3 Manual Fuels Reduction Projects

Manual fuels reduction projects under Alternative 1 are managed with the same restrictions as regular landscape maintenance projects in the park. Therefore it is not expected that there will be any negative impacts to species of special concern.

Alternative 1 does not propose mechanical fuels reduction projects or herbicide treatments on fire management projects.

3.1.8.1.4 Species of Special Concern Alternative 1 Cumulative Effects

Past, current and reasonably foreseeable actions that may contribute to cumulative impacts to special status species and their habitat include ongoing development which could reduce habitat or injure individual species. Fire and other management activities within the park which could impact individual species of concern. Traffic along roads, wildland fires and development on adjacent lands can all temporarily or permanently disturb or displace local wildlife species of special concern, therefore cumulative impacts could occur under the Alternative 1. Cumulative impacts could occur if mechanical/manual treatments, wildfire, or prescribed burns occur at the same time as development or planned/unplanned ignitions by landowners or agencies in adjacent areas, trail development in the park, and trail and road maintenance in the park. Such circumstances could compound the effects of temporary displacement on wildlife species by making habitats to which disturbed wildlife otherwise could escape also temporarily unsuitable. This could result in additional expenditure of energy and increased breeding and foraging competition. However, surviving individuals would be expected to repopulate disturbed areas over time. The continued growth and development in the surrounding area could contribute to the conversion of habitat for special status species to developed lands outside the park. This would increase habitat fragmentation and loss of habitat in the area, which has caused habitat degradation and degradation to ecosystem function in the region. Bats and bald eagles are capable of escaping wildfires, prescribed fires and mechanical/manual treatments and could occupy adjacent habitat during disturbance and until habitat is restored. Adverse cumulative impacts to special status species could occur from wildfires, because they have potential to alter or remove special status species' habitat, and could cause injury or mortality to individual special status species. There would be adverse impacts to some species during mechanical treatments as a result of temporary human disturbance, direct mortality from crushing and trampling, and loss of forage and cover.

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However, such impacts would be short term, limited to the duration of treatment activity and are not likely to be substantial or rise to population-level effects.

Both alternatives could result in short-term adverse impacts to wildlife during fire suppression activities. Suppression activities related to unplanned ignitions would last the duration of the wildfire event but most wildlife species would be able to escape the area and utilize adjacent habitat.

Impacts to wildlife from prescribed fires would include wildlife mortality and displacement due to habitat loss. Less severe prescribed fires would result in mortality and displacement of a few localized individuals or groups of animals and would not jeopardize population trends. Thus adverse effects would be short term.

Overall, fire management activities are expected to have a long-term beneficial effect on wildlife as open, fire-maintained pine and oak woodlands are restored and maintained within the park.

3.1.8.2 Species of Special Concern Impact Analysis for Alternative 2 – Preferred Alternative

Alternative 2 allows fire managers to manage wildfire for multiple objectives. Alternative 2 also allows fire managers to use prescribed fire (broadcast burning and handpile burning) as well as mechanical/manual fuels reduction methods, including mastication/brush hogging, machine and hand piling of slash as well as herbicide use. Fire effects of wildfire operations and prescribed fire operations on species of special concern are the same as they were for Alternative 1.

3.1.8.2.1 Wildfires

Types of impacts from wildfire and wildfire operations to species of special concern are the same as for Alternative 1. In alternative 2 there is a possibility that wildfires will over time become less intense and therefore easier to suppress as future increases in ecological burning and hazard fuel treatment under Alternative 2 modify fuels over a greater area. Alternative 2 also has the potential for larger wildfires as managers are allowed to manage wildfires for multiple objectives. The historical incidence of wildfires in the park is low, average of 1 fire per year burning an average of 0.5 acres so there are not a large number of opportunities to use wildfire for multiple objectives. This could be a direct benefit to fire adapted species and is not a concern for non-fire adapted species as the presence of a listed non-fire adapted species would lead a fire manager to completely suppress the fire at minimum acreage. All wildfires would have available a Resource Advisor if known species of special concern were in the vicinity. Use of wildland fire for multiple objectives could result in the temporary displacement of wildlife or individual mortality of wildlife species. Wildland fires would have an immediate effect on wildlife and wildlife habitats by removing plant material, exposing soils, stimulating growth of some plants, and killing or reducing the vigor of some plants. The amount of habitat removed may depend on the following fire characteristics: size, severity, patchiness, and time of year. The loss of habitat would have an indirect, short-term minor effect by displacing wildlife.

3.1.8.2.2 Prescribed Fire

Types of impacts from prescribed fire operations to species of special concern are the same as described for Alternative 1. In Alternative 2 the prescribed fire program can increase to

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approximately 10,570 acres per 10 year period. These proposed acres will allow the park to maintain previously burned fire-dependent vegetation acres and add additional acres to fire-dependent communities an important goal of the park. Prescribed fires will continue to be planned and executed utilizing mitigation measures and best management practices designed to minimize impacts to species of special concern. Prescribed fire limitations are the same as for Alternative 1 with timing, ambient surface air temperature equal to 60 degrees Fahrenheit or above and location restrictions based on species consideration. To the extent that implementation of a prescribed fire program would enhance natural processes and biological diversity, the planned fires will have positive effects on fire-dependent plant communities and associated animals. Utilizing operational restrictions and consulting with USFWS during the planning stages of operations there are minimal effects to species of special concern anticipated due to the prescribed fire program.

3.1.8.3 Mechanical and Manual Fuels Reduction

Alternative 2 proposes approximately 600 acres of mechanical/manual fuel treatments (mastication/brush hogging and slash piling) over 10 years. These treatments could be stand-alone projects or they could be "stage 1" treatments designed to safely reduce high fuel loadings near prescribed fire control lines, setting the site up for "stage 2" prescribed burns. Mechanical/manual vegetation manipulation projects may also be used to remove encroaching vegetation or opening up stands to sunlight. Operations can include use of machinery to crush or scatter live and dead vegetation, chainsaws to lop and scatter standing vegetation or to provide cut to length vegetation that is chipped or piled and burned during the wet periods of the year. Operations take place during daylight hours and would generally finish in 1 to 2 weeks. There would be adverse impacts to some species during mechanical/manual treatments as a result of temporary human disturbance, direct mortality from crushing and trampling, and loss of forage and cover. However, such impacts would be short term, limited to the duration of treatment activity and are not likely to be substantial or rise to population-level effects. Mechanical/manual fuels treatment projects incorporate protective species of concern operational constraints and mitigations in their design and implementation. These are planned projects and as with prescribed fire projects need a site plan that includes pre-surveys and monitoring for species of concern. Consultation with USFWS would also occur during the planning stages.

3.1.8.3.1 Herbicides

Alternative 2 proposes approximately 1,500 acres receiving spot herbicide applications over a ten year period. The applications would be focused on individual or small groups of target plants (spot application technique), therefore the actual treated acres would be far less than 1,500 acres. Herbicides chosen for use in the park are designed to have little or no effect on species of special concern. As in normal spraying operations in the park mitigation measures are incorporated in the program that will result in little or no effects on species of special concern.

3.1.8.3.2 *Species of Special Concern Alternative 2 Cumulative Effect*s

Cumulative impacts of Alternative 2 would be the same as for Alternative 1.

Conclusion

Both alternatives could result in short-term adverse impacts to species of special concern during fire suppression activities. Suppression activities related to unplanned ignitions would

last the duration of the wildfire event but most wildlife species would be able to escape the area and utilize adjacent habitat.

Impacts to species of special concern from prescribed fires would include wildlife mortality and displacement due to habitat loss. Less severe prescribed fires would result in mortality and displacement of a few localized individuals or groups of animals and would not jeopardize population trends. The loss of habitat would have an indirect, short-term minor effect by displacing wildlife.

Use of wildfire for multiple objectives could result in the temporary displacement of wildlife or individual mortality of wildlife species in the direct path of the fire or fire management activities. Wildfires would have an immediate effect on species of special concern and their habitats by removing plant material, exposing soils, stimulating growth of some plants, and killing or reducing the vigor of some plants. The amount of habitat removed may depend on the following fire characteristics: size, severity, patchiness, and time of year. Given the expected size and frequency of wildfires and mitigation techniques used during the management of fire, the loss of habitat would have an indirect, short-term minor effect by displacing species of special concern only directly in the path of the fire and fire management activities.

Under Alternative 2 – *Preferred Alternative*, there would be adverse impacts to some species during mechanical/manual treatments as a result of temporary human disturbance, direct mortality from crushing and trampling, and loss of forage and cover. However, such impacts would be short term, limited to the duration of treatment activity and are not likely to be substantial or rise to population-level effects.

Overall, fire management activities are expected to have a long-term beneficial effect on wildlife as open, fire-maintained pine and oak woodlands are restored and maintained within the park.

3.2 Cultural Resources, Including Archeological Resources and Cultural Landscapes

Affected Environment

The cultural time line for the park covers 12,000 years of human history divided into pre-historic and historic periods. Representing these periods are 1,112 known archeological sites (prehistoric and/or historic), and 28 historic structures on the surface and in the cave.

The pre-historic periods extend from the Paleo-Indian Period to the Middle Mississippian Period. A short discussion of the pre-historic periods follows.

PaleoIndian Period (> 12,000 years ago): Over 12,000 years ago, small nomadic groups of people first wandered over the Kentucky landscape. PaleoIndian culture consisted of highly mobile hunter gatherer groups, traveling seasonally over long distances in order to follow big game herds and acquire materials to equip highly refined toolkits. Paleoindian material culture is frequently composed of limited and highly adaptive lithic tool technology. These toolkits were often highlighted by comparatively large lanceolate blades, crafted to serve a variety of functions and maintained for frequent and repeated use. Sites are typically ephemeral with limited lithic materials composed of regionally collected, high quality cherts. The shared knowledge of resource locations included the exploitation of quarry sites, animal migratory routes, and other predictable seasonal resources. Most of our knowledge of Paleoindian culture

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comes from select camps and big game butchering sites. So far, only a few spear points of the PaleoIndian period have been found in Mammoth Cave National Park.

Early Archaic Period (8000-6000 B.C.): The Early Archaic period dates from 8000 B.C. to 6000 B.C. in Kentucky. Early Archaic lifeways were similar to those of the Paleoindian period, with small hunter gatherer groups focusing on migratory big game herds that persisted after the Late Pleistocene. Several Early Archaic (8000-6000 B.C.) sites exist in Mammoth Cave National Park.

Middle Archaic Period (6000-3000 B.C.): As the numbers of people during the Middle Archaic grew, population pressure drove groups into loosely-defined hunting territories. Populations adapted to their local conditions, developing new tools and modifying seasonal movements and hunting and gathering strategies to take advantage of the resources within their own territory. In Mammoth Cave National Park, this slow adaption to local environments is reflected in an increase in the styles of projectile points, both for hand-thrown spears and atlatl darts, found from the Middle Archaic period (6000-3000 B.C.).
The exchange of material resources like chert, shells, and copper, as well as marriage partners persisted across this period.

Late Archaic Period (3000-1000 B.C.): During the Late Archaic period, people began making pottery, cultivating gardens and growing domesticated plants. It was near the end of the Late Archaic period that people began exploring Mammoth Cave and other caves in the area, collecting minerals they found. The most likely reason is that these minerals were valued for their medicinal properties and/or ceremonial uses. They were traded to other groups for food, shells, chert, and other goods.

Woodland Period (1000 B.C. to A.D. 900): During the Woodland period, populations grew and aggregated in larger groups. Groups were more sedentary than before and formed small semi-permanent villages. Along with the population increase and a more sedentary lifestyle, social organization changed from the loosely organized hunter/gatherer organization characteristic of the Archaic period, to more complex social organization where village and lineage elders exercised limited control over the group decisions and social and ideological practices. This increasing social complexity was reflected by changes in technology, economy, religion, and mortuary ceremonialism.

Mississippian Period (A.D. 900 to A.D. 1500): The Mississippian period followed the Woodland period and ended with the arrival of the first Europeans to America. This period lasted from approximately A.D. 900 to 1500. The Mississippian period was the period during which Native American cultures reached their greatest complexity. Monumental architecture in the form of large platform mounds, facilitated a more centralized ideology that developed at this time. A highly stratified social structure formed within ceremonial centers, all supported by intensive agriculture focused within the major river valleys extending from the Mississippi River Valley, throughout the Midwest, Southeast, and their periphery. In the Mammoth Cave area, there appears to be a decrease in the number of Mississippian sites compared to earlier periods. This is probably because the floodplain along the Green River is not very wide and does not offer much room for farming. Like their ancestors, the Mississippians did not live by farming alone. They also hunted, fished, and gathered wild plants.

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The historic period includes the broadly defined periods of state and national history that begin with the Early Settlement of Kentucky (1774-1825), and continues through the Depression Era (1929-1941). Specific to the National Park Service is the Mission 66 era (1956-1966) which was a decade-long period of extensive upgrade and expansion to the infrastructure and services of the system, built to support the growing middle class of America and its increased capacity to spend leisure time in the outdoors. Some of the structures and sites have been evaluated for their National Register eligibility and of those evaluated; eligible structures and sites have been listed.

A list of documented cultural resources which might be impacted by fire management operations is found in Table 6.

Table 6 List of National Register Listed Properties at Mammoth Cave NP

Mammoth Cave Multiple resource submission Contexts	Exploration and Settlement in the Mammoth Cave Area, c.1754-1927	Discovery and Early Uses of Mammoth Cave, 1798-1849	Commercial Cave Development and the Growth of Tourism in the Mammoth Cave Area, 1849-1926	Establishment of Mammoth Cave National Park, 1924-1941
Property Types	Churches	Cemetery	Commercial Cave Entrances and Related Structures	Civilian Conservation Corps Buildings and Structures
Individual National Register Nominations	Good Spring Baptist Church and Cemetery, Joppa Baptist Church and Cemetery, Mammoth Cave Baptist Church and Cemetery	Mammoth Cave Historic District, Old Guides Cemetery	Mammoth Cave Historic District, Old Guides Cemetery, Crystal Cave Historic District, Colossal Cavern Entrance, Great Onyx Cave Entrance	Mammoth Cave Historic District, Residential Area Historic District, Maintenance Area Historic District, Maple Springs Ranger Station, Three Springs Pumphouse, Bransford Spring Pumphouse, Superintendent's House

Visitors who venture off park roads might find farm building foundations, weathered fences and an occasional orchard, all remnants of the agricultural inhabitants who lived in the area prior to establishment of the park. Fires have the potential to effect these resources, with more intense burns having the potential to adversely affect these combustible resources.

Studies have indicated that some park caves and rock shelters were extensively utilized by prehistoric people. The cave environment has preserved materials, like textiles, woven sandals, botanical remains, torches, and coprolites, which would otherwise quickly decompose in above ground areas. Textile samples and the remains of foodstuffs have provided important information about the life-ways of prehistoric peoples. Only those materials that might be found in vegetated cave entrances will be at risk of affects from fire activity. However, these areas typically do not hold the stable conditions to preserve the combustible organic materials mentioned above. The probable risk of impacts by fire activity is low for these resources.

Cultural Landscapes

The park contains the following four identified cultural landscapes: Mammoth Cave Historic District, Residential Area District, Maintenance Area District and the Crystal Cave District. The park also maintains a database of the 81 cemeteries in the park. Public access to some of these cemeteries is required and will be a design factor in any planned non-emergency fire operation. Following is a short description of each district:

The Mammoth Cave Historic District is located underground in Mammoth Cave; it encompasses 91 acres, 11 structures and 1 object as well as representing a collection of underground resources not placed under a property type heading.

Residential Area District encompasses 20 acres and 6 buildings built between 1925 and 1949.

Maintenance Area District encompasses 9 acres, 2 buildings and 1 structure built from 1925 to 1949.

Crystal Cave District contains two structures associated with the business run initially by the Collins family providing access to the public to Crystal Cave. The Collins House (T-73) was the original structure built sometime in the early decades of the twentieth century. The structure is a single story framed building with a rear ell wing, both board and batten and clapboard siding are on the different elevations. The Crystal Cave Ticket Office was constructed in the early 1920s and is a framed dogtrot style building with clapboard siding.

3.2.1 Analysis of Alternatives and Impacts on Cultural Resources

In both Alternative 1 and 2 the fire management program largely focuses on two aspects of cultural resources; protection of known and discovered archeological resources and secondly on protection of the park's known and discovered cultural landscapes with their associated structures.

3.2.1.1 Cultural Resources Impacts of Alternative 1 - No Action

Archeological Resources

Under Alternative 1, fire management activities would include wildfire suppression and prescribed fire activities.

3.2.1.1.1 Wildfires

Archeological sites would continue to be at risk to wildfires that could result in loss or damage to sites, either directly by wildfire or firefighting activities. Under Alternative 1 suppression actions are designed to limit wildfires to minimal size providing protection to archeological resources located outside the wildfire burn area. Historically the park has experienced one fire per year approximately 0.5 acres in size. Specific impacts to archeological resources from unplanned ignitions would vary depending on the fuels and locations of artifacts (Hanes 2001; Ryan et al. 2012). Fires burning in grassland areas are typically of short duration and easier to suppress, meaning that prolonged heating would be minimal and damage to artifacts unlikely. Fires burning in the denser shrub and forested areas are more difficult to suppress resulting in longer duration burn times and increased surface and subsurface heating that would directly damage metal, ceramic, bone, stone artifacts, and stone and brick foundations (NPS 2005). Intense wildfires could cause discoloration of surface artifacts, burning of perishable materials, checkering or cracking of glass and ceramic artifacts, melting of metals, and distortion of historic structures from expansion of materials (Ryan et al. 2012). Structures and sites with

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flammable wooden elements are especially vulnerable to wildfires and fire suppression activities. If an unplanned ignition does occur in an area with sensitive archeological resources, it has the potential to cause long-term and permanent damage or loss of those resources.

Wildfire suppression techniques, such as the construction of fire lines and burnout operations, may cause direct effects to buried artifacts due to soil disturbance, impact damage from tools and compaction. Wildfires can expose previously unknown cultural resources, which can have a positive result, but also a negative one. The positive is that previously unidentified sites have been located, but the negative is that the artifacts and features are now exposed to erosion and at risk for looting. Under the existing FMP, fire suppression is performed using MIST guidelines reducing ground disturbance impacts. By using these mitigation measures and cultural resource advisors in fire management decisions, wildfire suppression activities would avoid negative impacts to archeological resources.

In the event of a wildfire, measures would be taken to limit damages to cultural resources. Wildfire suppression would be conducted in coordination with the park's cultural resource specialist or advisor who would assist in designing avoidance and mitigation measures for impacts of fire management activities and monitor operations, if the resource advisor is qualified to do so.

3.2.1.1.2 Prescribed Fire

Alternative 1 proposes up to 4,350 acres of prescribed fire over the next 10 years. The use of prescribed fire will reduce hazard fuels making any wildfire in the treated area less intense and indirectly less likely to damage archeological artifacts. The actual prescribed fire itself will be burned under cooler conditions, creating less intense fires thereby minimizing direct damage to unknown archeological artifacts. With the associated pre-planning involved in prescribed burning, resources to be protected including known sites, such as fence lines would be identified and protected prior to ignition.

Lower severity wildfire, a result of previous prescribed burning operations would require less intense and potentially damaging suppression actions, which would result in fewer negative impacts to archeological resources than if no fire management activities to reduce fuel loadings were allowed to occur. Reductions of fuel loading would provide significant protections to surface and subsurface cultural artifacts that would otherwise be subject to long flame residence times. Prior to initiating a prescribed fire, the NPS would develop a prescribed burn plan, which would include advanced coordination with cultural resource staff to identify sensitive cultural resource locations and protocols for burning near cultural resources. Cultural resources would be identified and located as part of the prescribed burn plan process. Section 106 compliance would be completed for prescribed burn plans with the appropriate SHPO. Consultation will include efforts to develop and evaluate alternatives or modifications to the plan that could avoid, minimize or mitigate adverse effects on historic properties. Preparations might include manually removing fuels on or around the cultural resource; removing heavy logs and fuels from vulnerable areas; removing or covering stumps with dirt, foam, or retardant where burnout could affect subsurface cultural resources; or modifying the burn prescription to reduce fire intensity. All prescribed fire would be carefully managed and implemented using prescribed burn planning, MIST techniques, and oversight by cultural resource advisors. Close monitoring of the prescribed burn would be conducted to avoid negative impacts to recorded archeological sites and protection of newly discovered sites. Through adherence to these and

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other mitigation measures, impacts to cultural resources from prescribed fire would be short term and minimal.

3.2.1.1.3 Manual Fuels Reduction Treatments

Manual fuels reduction operations of mowing, blowing and raking leaves and chainsaw use to cut debris has the beneficial effect of reducing hazard fuels around wildland urban interface areas as well as park infra-structure. These operations occur in established areas where archeological resources have been identified and therefore would have no negative effect on those resources.

3.2.1.1.4 Mechanical Fuels Reduction

Alternative 1 does not allow for mechanical fuels reduction.

3.2.1.1.5 Herbicide

Alternative 1 does not allow fire management program use of herbicides.

3.2.1.2 Cultural Landscapes

Wildfires can burn structures as well as vegetation associated with a cultural landscape. Fuels reduction activities such as prescribed fire and mechanical/manual fuels reduction projects are important to the park in managing build-up of fuels in cultural landscape areas. Although these actions might impact a cultural landscape to a degree the reduced potential for more intense wildfires could save most of the elements of the cultural landscape.

3.2.1.2.1 Wildfires

Alternative 1 proposes keeping wildfire size to a minimum. Wildfire would, depending on its severity, diminish the visual integrity of cultural landscapes. Short-term adverse impacts would include unsightly burned and scorched vegetation and unvegetated areas. These areas would revegetate within a growing season, but the burned and scorched vegetation could persist for many years until falling over and being concealed by growing vegetation and becoming part of the ground litter layer. Intense wildfires could also result in the removal of important cultural landscape features, resulting long-term adverse impacts if buildings and structures are consumed by fire.

Wildfire operations would have little impact on known structures within a cultural landscape because fire managers would use mitigation measures to protect those structures. Wildfire suppression actions can modify vegetation associated with the cultural landscape and if used foaming agents as well as fire retardant can stain structures. Actions implemented to protect a cultural landscape from burning prior to the arrival of the fire could be removal of flammable vegetation near structures to be protected, fireline construction to limit ground fire spread and use of water and foaming agents in pre-wetting operations..

3.2.1.2.2 Prescribed Fire

The use of prescribed fire would increase the park's ability to reduce understory brush density, increasing the reduction of hazardous fuels and success rate of ecological restoration efforts to fire-adapted habitats. This would increase the potential for lower intensity ground fires, which are easier to manage, thus reducing the potential risk of damage to cultural landscapes. These lower intensity ground fires would help maintain more open forest structures within the cultural landscapes. Impacts to cultural landscapes under Alternative 1 would be long term and beneficial due to minimizing the potential for future severe wildland fires as the amount of

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acres restored increases and undergrowth brush density decreases. Short-term adverse impacts from prescribed burning would be the same as for wildfires.

Preplanning for prescribed burns requires input from cultural resource specialists resulting in a documented plan detailing mitigation measures protecting cultural landscapes that must be incorporated into the operations of any prescribed fire. Prescribed fire operations would therefore have very little impact on known cultural landscapes and associated structures.

3.2.1.2.3 Manual Fuels Reduction Treatments

Manual fuels reduction operations of mowing, blowing and raking leaves and chainsaw use to cut debris has the beneficial effect of reducing hazard fuels around wildland urban interface areas as well as park infra-structure. These operations occur in established areas where cultural landscapes have been identified and therefore would have no negative effect on those resources and would have the positive effect of reducing hazard fuels in these areas.

3.2.1.2.4 Mechanical Fuels Treatment

Alternative 1 does not allow mechanical fuels reduction projects.

3.2.1.2.5 Herbicide Use

Alternative 1 does not allow fire management use of herbicides for fire management operations.

3.2.1.3 Cultural Resources Alternative 1 - No Action Cumulative Impacts

Impacts to cultural resources are generally negative and long-term because there is a finite inventory of cultural resources. Fire management program negative impacts to cultural resources can add to negative impacts from other National Area operations such as road and trail building, new facilities construction and many maintenance operations. Additionally other federal, state, county and private operations have a potential to negatively impact cultural resources of the area. It is expected that the National Area fire management program and the completion of compliance with Sec 106 NHPA consultations, the use of cultural resource advisors and implementation of mitigation practices designed to protect cultural resources that cumulative impacts will be minor to cultural resources in the area. Present or reasonably foreseeable future projects at the park would undergo evaluation under Section 106 of the NHPA. Through this process, effects to cultural resources would either be avoided, minimized, or mitigated. Unanticipated discoveries during proposed activities typically results in work ceasing in the area and a qualified NPS staff member visiting the site to assess conditions and recommending a course of action in consultation with the Kentucky SHPO. Therefore, there would be no cumulative adverse effects to prehistoric or historic sites or cultural landscapes at the park under Alternative 1 from planned actions by the NPS and other entities. Beneficial long-term management would occur to cultural resources resulting from the future archeological inventory survey of vulnerable archeological sites within the park.

3.2.1.4 Cultural Resource: Impacts of Alternative 2 – Preferred Alternative

Alternative 2 focuses on the same two aspects of cultural resource protection as Alternative 1: 1. protection of archeological resources and 2. protection of the park's cultural landscapes.

Alternative 2 includes the same fire management activities as Alternative 1, wildfire suppression and prescribed fire. In addition Alternative 2 includes managing wildfires for multiple objectives, mechanical/manual fuels reduction techniques and use of herbicides.

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3.2.1.4.1 Wildfires

Impacts to archeological resources due to wildfire suppression actions are the same as in Alternative 1. Potential exists to affect known and unknown archeological resources. Fire management staff will continue to coordinate with Mammoth Cave NP cultural resource staff, NPS Southeast Regional staff, Southeast Archeological Center, and appropriate tribal groups to avoid known cultural sites and historic structures. Archeological resource protection measures include limiting ground disturbance intensity by using hand tools, blowers, or chainsaws to construct firelines. And not using fire retardant or fire foams. Where appropriate, mowing would continue around cultural features to remove accumulations of fuels to maintain defensible space.

A significant change in Alternative 2 is that fire managers can manage wildfire for multiple objectives. The result is that acreage burned by wildfires can be larger under this alternative. Wildfire burned acreage is not expected to increase very much because the number of wildfire starts still only averages one start per year. Restrictions on where and how intense a wildfire is allowed to burn will limit acreage and potential for negative impacts. Some resources that have not been documented may be present in areas where wildfires burn vegetation (e.g., archeological sites that have become overgrown by vegetation or in areas that have never been surveyed). Potential adverse effects to archeological resources could result from using wildfire for multiple objectives, as described for unplanned ignitions under Alternative 1. Protection of known archeological sites is still a priority and fire managers can suppress fires near known sites.

3.2.1.4.2 Prescribed Fire

Prescribed fire program impacts to archeological resources are the same as in Alternative 1. Alternative 2 does propose approximately 10,570 acres of combined prescribed burning over a ten year period. The same potential exists for damage to archeological resources during a prescribed fire operation as exists for a suppression operation as described in Alternative 1. The increased burned acreage could expose and damage unknown sites but the impacts to known sites would be minor due to pre-burn mitigation protection measures which either avoid or protect the site. Pre-operational surveys for unknown cultural artifacts and known cultural artifacts by qualified personnel helps minimize effects. The advantage of a controlled prescribed fire is that managers have time to assess potential effects on archeological resources and can adjust the project to protect those resources.

3.2.1.4.3 Mechanical Fuels Reduction

Alternative 2 proposes approximately 600 acres of mechanical/manual fuels reduction projects over the next 10 years. Projects would be developed for areas around the visitor center, housing and maintenance areas and areas adjacent to the wildland urban interface. Machinery used in mastication/brush hogging operations can directly damage archeological resources through cracking or crushing. These activities reduce fuel loadings in and around cultural resources reducing wildland fire intensities and fire duration. The result is less intense fires of shorter duration which will not impact archeological resources as much as fires in untreated areas. Human access with associated tampering and potential looting to unknown cultural artifacts increases in the proposed approximate 600 acres of operational areas under Alternative 2. These negative impacts are reduced through pre-operations surveys and monitoring during operations.

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3.2.1.4.4 Herbicide Use

Alternative 2 proposes potential spot herbicide treatments of approximately 1,500 acres over the next 10 years associated with the fire program. Access to these areas will increase over Alternative 1 (no fire management herbicide treatments). Although access increases, pre-surveys will be completed, fire management operational opportunities for discovery will have ended so herbicide applications would be the third entry on a site with a low probability for new finds.

3.2.1.5 Cultural Resources: Alternative 2 - Preferred Alternative Cumulative Effects

The types of cumulative effects to cultural resources under Alternative 2 would be the same as Alternative 1. The difference will be the scale of newly opened understory and potential increased risk of unanticipated cumulative affects caused by managing wildfire for multiple objectives under Alternative 2. Fire managers will work closely with resource managers to respond in those areas where documented cultural resources have been identified and are of greatest concern for protection. Fuels management and defensible space design should include any of those resources of greatest concern for affects caused by fire activity.

Conclusion

Affects to cultural resources may be adverse depending on the nature and intensity of any wildfire and subsequent fire management response and rehabilitation activities. Effects on cultural resources from planned fire management actions would be avoided or minimized through identifying the resources prior to disturbance and protecting the resources. However, during wildfire management activities unidentified archeological sites sometimes cannot be avoided, and because professional expertise and many of the mitigation measures listed may be unavailable for some areas, archeological resources could suffer direct, adverse effects.

Direct damage to or loss of historic structures and sites from wildfire and wildfire suppression activities would result in adverse effects to these resources. The effects on historic structures from fuel reduction projects, should be avoided or at least minimized by organizing defensible space around these structures and managing fires to burn at low intensities. Through these actions, the long-term management benefits as a result of reduced fire risk. The use of prescribed fire could restore the adjacent landscape to a setting more like the historic period and have beneficial long-term impacts. Mitigation that provides a preservation “net benefit”, would be required in those cases where adverse effects occur.

Fire or suppression activities could have adverse effects on cultural landscapes as viewshed changes could result in loss of trees and structures, burned vegetation and stumps, and exposed soils in fire lines altering the character of the landscape. Some effects could be short-term because vegetation may regenerate. Alternatively, fire can also have long-term management benefits for cultural landscapes as vegetation composition can be altered beneficially on a large scale with fire resulting in maintaining and even partially restoring the historic extent of native plant communities.

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Appendix 2: Fire Management Mitigation Measures and Best Management Practices

The NPS places a strong emphasis on avoiding, minimizing, and mitigating potentially adverse environmental impacts. To help ensure the protection of natural and cultural resources, protect the safety of firefighters and the public, and promote biodiversity and ecosystem health, the mitigation measures and Best Management Practices (BMP) discussed below would be implemented as part of the Proposed Action.

General

Whenever consistent with safe, effective suppression techniques, the use of natural barriers and existing human-made features would be used as extensively as possible.

Fire-retardant agents must be on an approved list for use by the U.S. Forest Service and the U.S. Department of Interior.

Earthmoving equipment such as tractors, graders, bulldozers, or other tracked vehicles would not be used for fire suppression. The superintendent can authorize the use of heavy equipment in extreme circumstances in the face of potential loss of human life and/or property.

MIST techniques would be used when constructing control lines. Leaf blowers, use of wet line, and other line-building techniques that would not disturb the soil would be used, especially in cultural sites. If possible, an archeologist or resource advisor would make the line in advance of the crews to avoid critical areas.

All sites where improvements are made or obstructions removed would be rehabilitated to pre-fire conditions, to the extent possible.

Air Quality

A prescribed fire plan (or burn plan) would be developed to meet specific vegetation management objectives and would be developed for each prescribed burn unit. Variables considered in the prescription would include wind parameters and smoke-sensitive receptors, fuel moistures, temperature, firing methods, timing of burn seasonally, relative humidity, and smoke dispersion. Prescribed burn plans would outline prescription windows for appropriate weather, fuel, fire behavior, fire management staffing, and social considerations.

Media releases would be used to inform the public and park visitors about wildland fire, informing them about potential smoke impacts, closures, or restrictions. Signs would be used throughout the park to inform visitors, and caution signs and/or lead vehicles would be used where smoke may impact transportation corridors inside and outside the park. If necessary, the superintendent would authorize temporary closure of some areas to the public and visitors.

Other agencies would be notified by park staff for all prescribed burns. Each burn plan would contain a list of contacts, including park neighbors and adjoining landowners who may experience more immediate visual impacts from fire operations, or movement of personnel and equipment associated with prescribed burns. MACA staff is responsible for notifying those on the contact list.

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Park staff would coordinate with adjacent agencies, landowners, and infrastructure owners/operators regarding prescribed burn planning to limit potential smoke impacts from affecting transportation routes, sensitive receptors, and infrastructure within or adjacent to the park.

Prescribed fires would be planned to limit effects of prescribed fire smoke during holidays, special events, and busy visitation periods, when possible. However, prescribed burns could occur during these times, if approved by the park superintendent. Superintendent approval is required prior to ignition.

Timing and methods of ignition on prescribed burns would be constantly assessed and reviewed by fire managers to minimize smoke impacts. Personnel would be trained in emission reduction techniques as outlined in the National Wildfire Coordinating Group (NWCG) Smoke Management Guide (Hardy et al. 2001) and continuous monitoring would be required throughout the burn.

Sensitive smoke receptors would be identified during planning. On the day of the burn, the burn boss would assess wind direction, transport winds, and dispersion prior to ignition. If plume trajectory maps reveal that sensitive smoke receptors would be impacted by the burn and the impacts cannot be mitigated, the burn may be rescheduled.

All prescribed burning and pile burning will comply with the Commonwealth of Kentucky State Implementation Plan Commonwealth of Kentucky 401 KAR 53:010. *Ambient air quality standards concerning air quality guidelines and smoke management regulations*.

Unhealthy or hazardous accumulations of smoke as determined by levels indicated in the Ky Smoke Implementation Plan will trigger an aggressive suppression action that will continue until air quality attains acceptable levels.

When adjacent land management agencies are managing prescribed fires or wildfires, cooperation and coordination will be initiated to minimize cumulative smoke impacts.

Natural Resources

The following fire management mitigation measures concerning vegetation resources would be implemented as follows:

1. **Non-native species invasion and fire management activities**: Recognizing that fire management activities cause disturbance, opportunities exist for non-native plant species colonization. For example, fire suppression has contributed to the invasion of non-native thistles in some areas. If non-native plants are found, natural resources staff will develop appropriate mitigation measures (i.e. cutting seed heads, herbicide treatments or manually removing plants). Additionally, staff will modify their prescribed fire practices if certain activities are determined to contribute to invasions of non-native plants.
2. **Pile burning**: To ensure that impacts from pile burning would be minimized, piles would be kept small (typically four feet wide, eight feet long, and four feet tall) to minimize the extent of vegetation and soil damage, and also to allow mycorrhizal fungi

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and other soil organisms to re-colonize patches of sterilized soil. This would also facilitate nutrient cycling processes and help plants reestablish. Raking duff from adjacent areas over the burn-pile footprint will also be considered on a case-by-case basis for the operational plan when burning piles.

3. **Slash**: Debris from cut vegetation (slash) will either be lopped and scattered to a depth of no more than 18 inches and burned during a subsequent prescribed fire, or piled and burned separately.

The following fire management mitigation measures concerning wildlife resources would be implemented as follows:

1. Log jams/debris would be left in streams to protect fish and aquatic insect habitat.
2. Fire chemical use within the floodplain, wetlands, and other sensitive areas must be approved by the Superintendent and would adhere to the *Interagency Policy for Aerial and Ground Delivery of Wildland Fire Chemicals Near Waterways and Other Avoidance Areas* as described in Chapter 12 of the Interagency Standards for Fire and Fire Aviation Operations (U.S. Department of the Interior and U.S. Department of Agriculture 2016) or future revised version.
3. Park resource specialists would be involved during and after wildfire and during prescribed burn planning to ensure that prescriptions and burn objectives do not conflict with objectives for the protection of sensitive vegetation and wildlife populations and habitat. The park would coordinate with the applicable USFWS field office, as needed.
4. The use of large mechanized equipment would require superintendent approval.
5. Transport of fire personnel and equipment would use existing roads and trails wherever possible.
6. Aviation use would be carefully considered and impacts to wildlife mitigated through timing of operations, exclusion of low-level aviation use, or avoidance of certain areas of the park.
7. Fire effects monitoring on species and habitat would be used to inform multi-entry prescribed burning and ecosystem maintenance activities.
8. Fire management personnel would be briefed on potential resources of concern and known locations within a burn unit in order to facilitate avoidance potentially sensitive resources.
9. Mop-up methods would use MIST techniques to protect natural resources, including soils, water resources, vegetation, and wildlife.

The following fire management mitigation measures concerning species of special concern would be implemented as follows:

The park would consult with the USFWS for effects to federally listed species when developing individual prescribed burn plans.

During the planning phase of any fire management activity, the presence of special-status species in the area will be determined. Park personnel will evaluate existing databases and maps and may request additional surveys for field verification. Site-specific mitigation measures will be developed in the biological assessment that is provided to the Fish and

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Wildlife Service and will be followed. If a prescribed fire unit includes habitat for special-status species, actions will be taken to avoid nesting season and/or other sensitive periods for plants and animals. Providing direct protection of certain areas (such as nesting trees), altering the time or season of burning, or simply not allowing fire into parts of the unit are examples of possible mitigation measures for sensitive plants and wildlife. All suppression activities necessary to extinguish a fire will follow current MIST.

Prescribed fire and mechanical/manual clearing, removing, or thinning trees, including snags, would occur between September 1 and April 30 (outside the roosting or maternity season) minimizing the potential for eliminating a roost tree and injuring or killing federally listed bat species. Potential roost trees would not be cut during the period when the bats occupy their summer range. If prescribed fire is used or trees must be removed outside these dates, ESA Section 7 consultation would be reinitiated with USFWS.

Specific to managing unplanned and planned ignitions fire for multiple objectives, the park would implement the following mitigation measures:

1. After providing for public and firefighter safety, attempt to prevent any wildfire from burning to within 0.25 miles of a known hibernaculum
2. After providing for public and firefighter safety, attempt to prevent any wildfire from burning to within 150 feet of a known maternity roost tree, if identified within the park
3. Contact the appropriate USFWS Ecological Services Office as soon as it is practical to do so in the event of any wildfire that burns within 0.25 miles of a known hibernaculum or 150 feet of a known maternity roost tree, or that occurs during the maternity season (approximately April 1 – August 15). *Note: This procedure follows the "Emergency Consultation Process" as defined by USFWS.*
4. Park resource specialists would be involved during and after wildfire and during prescribed burn planning to ensure that prescriptions and burn objectives do not conflict with objectives for the protection of sensitive vegetation and wildlife populations and habitat. The park would coordinate with the applicable USFWS field office, as needed.
5. In the event of a wildfire, resource specialists would examine maps and information resources to assess and discuss potential effects of the fire.
6. Aviation use would be carefully considered and impacts to wildlife mitigated through timing of operations, exclusion of low-level aviation use, or avoidance of certain areas of the park.
7. Fire effects monitoring on species and habitat would be used to inform multi-entry prescribed burning and ecosystem maintenance activities.
8. Fire management personnel would be briefed on potential resources of concern and known locations within a burn unit in order to facilitate avoidance of habitat for special status species or other potentially sensitive resources.

Additional mitigation measures specific to special-status plants:

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1. Where possible, avoid ground-disturbing activities, such as line construction, manual or mechanical/manual treatments, or pile burning, in areas of known special-status plant populations and in areas of suitable habitat
2. Only in emergencies, construct fire line through suitable habitat by using natural barriers, such as the streambed, to delimit the burn area. As a last resort, if no natural barriers exist, construct fire line by using minimal line construction techniques (i.e. removal of duff layer only) to link natural barriers. All constructed fire lines would be rehabilitated.
3. Monitor special-status plant response to fire management activities.

The timing restrictions related to bat species listed above for prescribed burns and mechanical/manual treatments would also provide protection for migratory bird species during the bird nesting season as required under the Migratory Bird Treaty Act.

Log jams/debris would be left in streams to protect fish and aquatic insect habitat.

Control line construction would be permitted in the floodplain or in wetlands during emergency response situations, as long as MIST is used. Control line construction within wetlands and floodplains would be avoided for prescribed burns.

Control lines would be located outside highly erosive areas, steep slopes, and other sensitive areas wherever possible. Following fire suppression activities, control lines would be recontoured, water barred, and material raked off would be replaced.

Fire chemical use within the floodplain, wetlands, and other sensitive areas must be approved by the Superintendent and would adhere to the *Interagency Policy for Aerial and Ground Delivery of Wildland Fire Chemicals Near Waterways and Other Avoidance Areas* as described in Chapter 12 of the Interagency Standards for Fire and Fire Aviation Operations (U.S. Department of the Interior and U.S. Department of Agriculture 2016) or future revised version.

Park resource specialists would be involved during and after wildfire and during prescribed burn planning to ensure that prescriptions and burn objectives do not conflict with objectives for the protection of sensitive vegetation and wildlife populations and habitat. The park would consult with the applicable USFWS field office, as needed.

To reduce potential for the spread of invasive species, all equipment used for fire management activities would be washed and inspected prior to the burn.

Wherever possible, natural features and existing human-made barriers would be used for containment lines to minimize additional disturbance to soils.

The use of large mechanized equipment would require superintendent approval.

Transport of fire personnel and equipment would use existing roads and trails wherever possible.

In the event of a wildfire, resource specialists would examine maps and information resources to assess and discuss potential effects of the fire.

Aviation use would be carefully considered and impacts to wildlife mitigated through timing of operations, exclusion of low-level aviation use, or avoidance of certain areas of the park.

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Fire effects monitoring on species and habitat would be used to inform multi-entry prescribed burning and ecosystem maintenance activities.

Fire management personnel would be briefed on potential resources of concern and known locations within a burn unit in order to facilitate avoidance of habitat for special status species or other potentially sensitive resources.

Mop-up methods would use MIST techniques to protect natural resources, including soils, water resources, vegetation, and wildlife.

If a major wildfire occurs, the use of Burned Area Emergency Rehabilitation teams would be considered through consultation with the NPS Southeast Regional Office and park resource specialists.

Park resource specialists would monitor wildfire locations for exotic plant invasions and manage as necessary.

Cultural Resources

Pre-Incident Planning

1. Planning for fire management actions will include avoidance and minimization of effects on known cultural resources using various measures as recommended by cultural resource staff.
2. Cultural resource inventories will be completed for each fire management project area to identify resources that may be significant and are susceptible to adverse effects from fire or fire management actions.
3. Known cultural resources will be evaluated for fuels, and those fuels may be reduced as part of ongoing fuel reduction programs.
4. The park will continue to consult with Native American tribes about fire management planning and specific fire management actions in order to identify issues and resources of concern and to implement the most appropriate treatments.
5. The park would continue coordination with the Southeast Archeological Center to ensure that the park has the most current data regarding archeological resources within its boundaries. The park's cultural resource specialist(s) would provide recommendations on how to mitigate adverse effects on these resources during fire management activities and would coordinate compliance with Section 106 of the National Historic Preservation Act, as appropriate.
6. The park will continue to work with the Southeast Archeological Center to use existing and develop better site prediction GIS models that can be used to guide placement of staging areas for equipment, cutting fire breaks, etc. to avoid areas of high site probability to the extent practical.
7. Historic structures and sensitive cultural sites would be protected from wildland fire via fuel reduction plans in an effort to provide defensible space.

The possible effects of fire and fire management activities on cultural resources will be mitigated by the following actions:

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1. Prior to the start of work, archeologists, cultural resource specialists, or other resource management staff will instruct crews in identification of cultural materials and will review federal and state laws protecting archeological sites and artifacts.
2. All cultural sites within the project area will be identified and located by an archeologist, cultural resource specialist, or other resource management staff member. These sites should be avoided during fire management activities.
3. An archeologist, cultural resource specialist, or resource management staff member will be integrated into planning and response activities.
4. Following each project or treatment, a report will be sent to the SHPO

Incident Response

1. Fire management teams will solicit the advice of archeologists, cultural resource specialists, and/or other resource management staff on cultural resource issues and concerns to avoid affects to cultural resources.
2. Except in wildfire initial attack situations, an archeologist or resource advisor would be assigned to a fire crew to locate the control line in advance of line construction activities.
3. To avoid affects to cultural resources, archeologists, cultural resource specialists, and/or other resource management staff will, whenever possible, aid in positioning crew camps, holding lines and other fire suppression-related activities in culturally sensitive areas.
4. Archeologists, cultural resource specialists, and/or other resource management staff will be assigned as resource advisors to fire management teams to advise of known significant cultural resources in areas where potential effects of fire could be avoided or minimized through emergency fuel reduction.
5. During all suppression activities, MIST guidelines would be incorporated to the greatest extent feasible and appropriate for the given situation. Tactics directly or indirectly facilitating the protection of archeological/cultural/historic resources include:
    a. Keeping engines or slip-on units on existing roads;
    b. Not using heavy equipment (e.g., bulldozers, plows) for constructing control line;
    c. Not using fireline explosives in areas of known cultural resource significance;
    d. Using existing natural fuel breaks and human-made barriers, wet line, or cold trailing the fire edge in lieu of fireline construction whenever possible;
    e. Keeping fireline width as narrow as possible;
    f. When necessary, mapping, marking, or flagging cultural resources during wildfire suppression, rehabilitation, and prescribed burn implementation (and removing flagging immediately after the fire event); and
    g. Providing all workers with basic training about cultural resources.

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h. Ground disturbance would be avoided within known archeological/cultural/historic resource locations. When control line construction is necessary in proximity to these resource locations, it would involve as little ground disturbance as possible and be located as far outside known resource boundaries as possible. A resource advisor or archeologist would check this control line for possible site disturbance immediately following the wildland fire event.

i. Soaker hoses, sprinklers, or foggers would be used in mop-up, avoiding boring and hydraulic action.

j. The park's cultural resource specialist(s) would be contacted immediately if previously unrecorded cultural resources are discovered during any wildland fire operations. The cultural resources would be recorded, delineated, and protected.

k. In instances of wildfire, a post-fire data recovery and/or restoration program would be developed that is sensitive to cultural resource concerns.

Visitor Use and Experience

1. Firefighter and public safety would be the highest priority in all fire management activities.
2. Prescribed fires would not be ignited in proximity to park structures when prevailing winds carry smoke towards the structures.
3. The park would notify the public of upcoming prescribed burning operations and management of wildfires through press releases and social media. Prescribed fire notifications and fire information would be posted at public locations, such as trailheads, parking areas, and visitor centers.
4. Educational outreach would be implemented prior to any closure or restrictions to explain the role of fire as a management tool.
5. Fire management staff would work with protection staff and local agencies on posting smoke hazard signs if smoke could impact roadways.
6. Fire staff would coordinate closely with rangers to determine the location of visitors and use road/trail closures and restrictions to ensure prescribed fire or wildfire operations do not put visitors at risk.
7. Visitors would be excluded from the immediate vicinity of the wildfire or prescribed burn when fire management activities are underway.
8. Weather conditions would be closely monitored during the prescribed fire or managed wildfire to ensure that any changing conditions do not suddenly put visitors at risk.
9. Following a wildland fire and as burned areas are opened to visitors, signs would be used to inform visitors of the potential hazards (e.g., snags, stumps, and holes).

Appendix 3: List of Mammoth Cave NP Classified Structures

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Table App3-1: Mammoth Cave NP Classified Structures

Count	Park	ID Number	Name	State	Status
1	MACA	021	Maple Springs Residence	Kentucky	Local
2.	MACA	024	Three Springs Pump House	Kentucky	Local
3.	MACA	024A	Three Springs Area Retaining Walls	Kentucky	Local
4.	MACA	025	Bransford Spring Pump House	Kentucky	Local
5.	MACA	025A	Bransford Spring Cistern	Kentucky	Local
6.	MACA	028	Residence #28	Kentucky	Local
7.	MACA	029	Residence #29	Kentucky	Local
8.	MACA	030	Residence #30	Kentucky	Local
9.	MACA	031	Residence #31	Kentucky	Local
10.	MACA	032	Residence #32	Kentucky	Local
11.	MACA	033	Residence #33	Kentucky	Local
12.	MACA	038	Superintendent's Residence	Kentucky	Local
13.	MACA	059	Repair Shop & Garage	Kentucky	Local
14.	MACA	060	Paint Shed / Oil House	Kentucky	Local
15.	MACA	063	Warehouse / Maintenance Building	Kentucky	Local
16.	MACA	C-02	Poplar Springs Cemetery Headstones	Kentucky	Not Significant
17.	MACA	C-03	Temple Hill Cemetery Headstones	Kentucky	Not Significant
18.	MACA	C-06	Miles-Davis Cemetery Headstones	Kentucky	Not Significant
19.	MACA	C-07	Brooks Cemetery Headstones	Kentucky	Not Significant
20.	MACA	C-11	Good Spring Baptist Church Cemetery Headstones	Kentucky	Local
21.	MACA	C-12	Parker Cemetery Headstones	Kentucky	Not Significant
22.	MACA	C-16	Joppa Baptist Church Cemetery Headstones	Kentucky	Local
23.	MACA	C-20	Wilkins Cemetery Headstones	Kentucky	Not Significant
24.	MACA	C-25	Wilson Cemetery Wall	Kentucky	Not Significant
25.	MACA	C-28	Old Guide's Cemetery Walled Graves	Kentucky	Local
26.	MACA	C-29	Eaton Grave	Kentucky	Not Significant
27.	MACA	C-35	Locust Grove Cemetery Headstones	Kentucky	Not Significant
28.	MACA	C-36	Little Hope Baptist Church Cemetery Headstones	Kentucky	Not Significant
29.	MACA	C-36A	Little Hope Baptist Church Cemetery Wall	Kentucky	Not Significant
30.	MACA	C-38	Cox #2 Cemetery Walled Grave	Kentucky	Not Significant
31.	MACA	C-41	Adwell Cemetery Headstones	Kentucky	Not Significant

Count	Park	ID Number	Name	State	Status
32.	MACA	C-44	Mammoth Cave Baptist Church Cemetery Headstones	Kentucky	Local
33.	MACA	C-51	Little Jordan Cemetery Headstones	Kentucky	Not Significant
34.	MACA	C-71	Dry Branch Cemetery Headstones	Kentucky	Not Significant
35.	MACA	C-73	Bransford Graves	Kentucky	Not Significant
36.	MACA	C-78	Slemmons-Davis Walled Graves	Kentucky	Not Significant
37.	MACA	C-81	Hayden Cemetery Headstones	Kentucky	Not Significant
38.	MACA	E-11	Frozen Niagara Entrance	Kentucky	Contributing
39.	MACA	E-13	Crystal Cave Entrance	Kentucky	Local
40.	MACA	E-16	Great Onyx Cave Entrance	Kentucky	Local
41.	MACA	E-19	Colossal Cavern Entrance	Kentucky	Local
42.	MACA	E-20	Violet City Entrance	Kentucky	Contributing
43.	MACA	E-21	Carmichael Entrance	Kentucky	Contributing
44.	MACA	HS-1	Historic Train "Hercules" and Coach #2	Kentucky	State
45.	MACA	HS-22	Maple Springs Office Building	Kentucky	Local
46.	MACA	HS2A-1	Leaching Vat #1, Rotunda	Kentucky	Contributing
47.	MACA	HS2A-2	Leaching Vat #2, Rotunda	Kentucky	Contributing
48.	MACA	HS2A-3	Leaching Vat #3, Rotunda	Kentucky	Contributing
49.	MACA	HS2A-4	Rotunda Drain Tank	Kentucky	Contributing
50.	MACA	HS2B-1	Leaching Vat #1, Booth's Amphitheater	Kentucky	Contributing
51.	MACA	HS2B-2	Leaching Vat #2, Booth's Amphitheater	Kentucky	Contributing
52.	MACA	HS2B-3	Leaching Vat #3, Booth's Amphitheater	Kentucky	Contributing
53.	MACA	HS2B-4	Leaching Vat #4, Booth's Amphitheater	Kentucky	Contributing
54.	MACA	HS2B-5	Leaching Vat #5, Booth's Amphitheater	Kentucky	Contributing
55.	MACA	HS2B-6	Leaching Vat #6, Booth's Amphitheater	Kentucky	Contributing
56.	MACA	HS3A	Consumptive Hut #1	Kentucky	Contributing
57.	MACA	HS3B	Consumptive Hut #2	Kentucky	Contributing
58.	MACA	IC-01	Saltpetre Pipes (Broadway)	Kentucky	Contributing
59.	MACA	IC-02	Mushroom Beds	Kentucky	Contributing
60.	MACA	IC-03	Rock Stairs and Walls to Olive's Bower	Kentucky	Contributing
61.	MACA	IC-04	Rock Stairs-End of Gothic Ave, thru Elbow Crevice	Kentucky	Contributing
62.	MACA	IC-05	Rock Wall at Bridal Altar	Kentucky	Contributing
63.	MACA	IC-06	Cable in Aerobridge Canyon	Kentucky	Contributing
64.	MACA	IC-07	Crystal Lake Landing	Kentucky	Contributing

Count	Park	ID Number	Name	State	Status
65.	MACA	IC-08	Rock Wall at Jenny Lind's Armchair	Kentucky	Contributing
66.	MACA	IC-09	Rock Wall at End of Gothic Avenue	Kentucky	Contributing
67.	MACA	IC-10	Gothic Avenue Rock Monuments, Walls & Signatures	Kentucky	Contributing
68.	MACA	IC-11	Albert's Stairway	Kentucky	Contributing
69.	MACA	T-40	Joppa Missionary Baptist Church	Kentucky	Local
70.	MACA	T-41	Mammoth Cave Baptist Church	Kentucky	Local
71.	MACA	T-43	Good Spring Baptist Church	Kentucky	Local
72.	MACA	T-73	Crystal Cave Ticket Office	Kentucky	Local
73.	MACA	T-74	Collins, Floyd House	Kentucky	Local

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Appendix 4 Fire Management Goals and Objectives

The following are the goals and objectives for the Park.

Goals	Objectives
1. Firefighter and public safety will receive the highest priority during every fire management activity	• No fire management operations will be initiated until all personnel involved receive a safety briefing describing known hazards and mitigating actions, current fire season conditions and current and predicted fire weather and behavior. • Fire management operations will be carried out only by fully qualified individuals that promote the safe and skillful application of fire management strategies and techniques, and who are familiar with the fuel and expected fire behavior. • Neighbors, visitors and the local residents will be notified of all planned and unplanned fire management activities that have the potential to impact them. • Park closures will be imposed at the discretion of the Superintendent to ensure public safety. • Conduct post-fire critiques to evaluate firefighter safety
2: Utilize the strategy of "Use of wildfire for resource benefits" where appropriate and suppress all wildland fires regardless of ignition source when there is a need to protect the public, check fire spread onto private property, and protect the natural and cultural resources of MACA.	• Suppress fires at minimum cost, considering firefighter and public safety, benefits, and values to be protected, consistent with resource objectives. • Employ minimum impact suppression tactics (MIST). Avoid adverse impacts to the natural and cultural resources. • Limit off road vehicle use in closed areas unless human life or private or public property are threatened. Limit heavy equipment use unless human life or private or public property are threatened. • Avoid adverse impact to water resources. • Do not use foam or retardant use unless approved by the Superintendent or their representative.
3: Facilitate reciprocal fire management activities through the development and maintenance of cooperative agreements	Develop and maintain fire agreements with the following agencies: • U.S. Fish and Wildlife Service • Kentucky State Department of Forestry • The Nature Conservancy

and working relationships with local fire management agencies.	• Local Fire Departments/Districts Conduct training on an interagency basis to the fullest extent possible.

4: Use prescribed fire where and when appropriate as a tool to manage vegetation within park boundaries, and where acceptable, across park boundaries to attain resource and fire management objectives.	• Conduct all fire management operations in accordance with approved plans.
	• Utilize prescribed fire to achieve resources management goals including the following:
	  ○ Hazardous fuel reduction around Wildland Urban Interface (WUI) to reduce wildfire severity
	  ○ Restoration of natural fire regimes
	  ○ Restoration and maintenance of unique landscapes
	  ○ Promoting desired species
	  ○ Restoring native plants and animal communities
	  ○ Reduction of exotic species
	• Monitor and evaluate the effects of fire management on the ecosystem in order to determine if objectives are met and utilize monitoring information as it becomes available to modify fire program objectives, strategies, and prescriptions.
	• Prescribed fire implementation and locations will incorporate ecological and economic factors as well as social values.
	• Cooperatively manage prescribed and wildland fires across park boundaries when and where appropriate.

5. Modify fuel complexes around developed areas, along wildland-urban interface boundary areas and in proximity of cultural sites to reduce fire behavior and intensity to a manageable level in order to protect critical sites.	• Use non-fire fuels reduction methods to reduce hazard fuel accumulations around boundaries and structures to reduce fire intensity and severity and to allow improved access by firefighting resources. • Use mechanical means to reduce accumulations of hazard fuel around vulnerable cultural and historic sites for protection from fire damage.
6: Promote public understanding of wildland fire management programs and objectives.	• Cooperate with other agencies to create a consistent fire management message and theme.
7: Manage wildland fires in concert with federal, state, and local air quality regulations to protect the air	• Address air quality as a part of the go-no-go decision process for all fire management actions. • Address air quality as a part of the alternative development and selection

quality of the local and adjacent airsheds.	decision process using the Wildland Fire Decision Support System. • Incorporate air quality objectives in each prescribed burn plan. • Develop and implement smoke impact mitigation measures in prescribed burn plans and all wildland fire management actions.

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Appendix 5: Minimum Impact Strategy and Tactics

(NPS Guidelines,)

MINIMUM IMPACT TACTICS GUIDELINES

NPS fire management requires the fire manager and firefighter to select management actions commensurate with the fire's potential or existing behavior, yet leaves minimal environmental impact. To assist firefighters in reducing short and long-term environmental impacts federal firefighting agencies have developed minimum impact tactics guidelines. A comprehensive look at these guidelines is found at the following link.
https://www.nps.gov/fire/wildland-fire/about/nps-reference-manual-18.cfm

Minimum Impact Strategy and Tactics are used in all fire management operations at MACA. The intent of utilizing MIST is to safely and effectively complete the fire management operation with minimal impact to resources.

Specific MIST procedures at MACA are:

- Any off-road use of vehicles, plows and other mechanized equipment must be approved by the Superintendent
- Any use of retardant will be reviewed by an assigned resource advisor and approved by the Superintendent
- Consider during mop-up: Cold-trailing fireline, using wetline or sprinklers as control line, using natural or human made barriers to limit fire spread, burning out sections of fireline, limiting width and depth of fireline necessary to limit fire spread
- Locate pumps and fuel sources to minimize impacts to streams
- Minimize cutting of trees and snags to those that pose safety or line construction concerns, prune lower branches to remove ladder fuels as opposed to falling the tree.
- Minimize bucking of logs to check/extinguish hot spots; preferably roll logs to extinguish and return logs to original position: scatter branches and other debris in accordance with guidelines contained in the Fireline Handbook (PMS 410-1)
- Utilize extensive cold-trailing and/or hot-spot detection devices along perimeter
- Use mop-up kits and other low pressure nozzles setting to prevent erosion
- Water bars will be placed on steep slopes

Tactics and equipment used for suppression and for holding operations on prescribed burns will be selected to minimize the impact commensurate with values at risk. Use of bull dozers or tractor plows is prohibited except with the permission of the Superintendent. In areas closed to public motorized use, vehicles will only be used when necessary for protection of sensitive resources, life, safety and private property. Snag falling will be limited to those trees necessary to secure control lines.

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Appendix 6: Alternative 1 No Action Alternative Proposed Project List

(Primary objective is ecological and secondary is fuel reduction.)

Table App6-1: Prescribed Fire Objectives for - *No Action* Alternative 1 Planned Projects

Project Name	Fire Objectives	Secondary Objectives	Acres
Wondering Woods (South)	Fuel reduction	Barrens Habitat Management: Enhance Eggbert's Sunflower	17
Wondering Woods (North)	Fuel reduction	Barrens Habitat Management	31
Temple Hill North	Mitigation project	Reduce Invasive understory species	29
Old Job Corps Site	Fuel reduction	Barrens Habitat Management: Enhance Eggbert's Sunflower	44
Bruce Hallow Glade	Fuel reduction and mitigation project	Savanna Habitat ; Reduce invasive understory species; Enhance state list species	41
Floating Mill Hollow	Fuel reduction	Comparative fire ecology	125
Houchins Valley	Fuel reduction	Reduce presence of fire intolerant pioneer species in relatively intact karst valley site	83
Great Onyx	Fuel reduction	Barrens Habitat Management: Enhance Eggbert's Sunflower	201
Jim Lee A	Fuel reduction	Perpetuate forest prairie hybrid savanna habitat and reduce encroachment by mesic species	101
Jim Lee B	Fuel reduction	Perpetuate forest prairie hybrid savanna habitat and reduce encroachment by mesic species	123
Jim Lee C	Fuel reduction	Perpetuate forest prairie hybrid savanna habitat and reduce encroachment by mesic species	154
Jim Lee D	Fuel reduction	Perpetuate forest prairie hybrid savanna habitat and reduce encroachment by mesic species	84
Wondering Woods (South)	Fuel reduction	Barrens habitat Restoration: Enhance Eggert's Sunflowers	17
Wondering Woods (North)	Fuel reduction	Barrens habitat Restoration	31
Joppa Church	Fuel reduction	Maintain or improve open savanna community type	51
Collins House	Fuel reduction	Protect Historic Structures and Barren Habitat	81

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Peanut Knob (North)	Fuel reduction and mitigation project	Reduce invasive understory species	39
Peanut Knob (South)	Fuel reduction and mitigation project	Reduce invasive understory species	28
Dennison Glade	Fuel reduction	Perpetuate forest prairie hybrid savanna habitat and reduce encroachment by mesic species	77
Dennison Ferry Sink	Fuel reduction	Perpetuate forest prairie hybrid savanna habitat and reduce encroachment by mesic species	22
Dennison Ferry Road	Fuel reduction	Perpetuate forest prairie hybrid savanna habitat and reduce encroachment by mesic species	83
Crumps Knob	Fuel reduction and mitigation project	Reduce invasive understory species	49
Brooks Knob	Fuel reduction and mitigation project	Reduce invasive understory species	39
Temple Hill North	Fuel reduction and mitigation project	Reduce invasive understory species	29
Old Job Corps Site	Fuel reduction	Barrens habitat Restoration: Enhance Eggert's Sunflowers	44
Great Onyx	Fuel reduction	Barrens habitat Restoration: Enhance Eggert's Sunflowers	201
Goblin Knob	Fuel reduction and mitigation project	Reduce invasive understory species	102 102
Whistle Mountain	Fuel reduction	Barrens habitat Restoration: Enhance Eggert's Sunflowers	22

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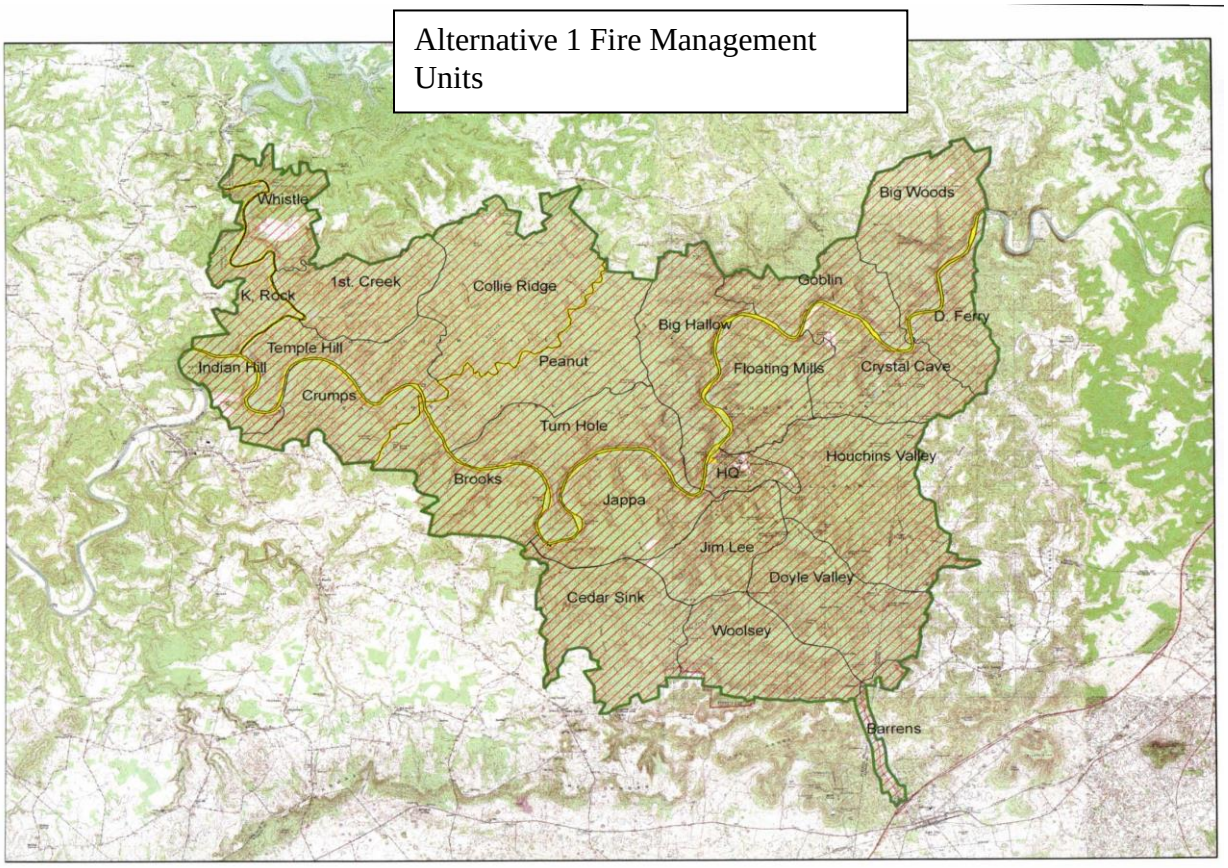
Figure App6-1: Alternative 1 *No Action* Fire Management Units



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Appendix 7: Alternative 2 *Managed Fire for Multiple Objectives*
Proposed Prescribed Fire Projects

Table App7-1: Alternative 2 - *Preferred Alternative* Proposed Prescribed Fire Projects

Name	Unique ID Number	Acres
New Job Corps	01	93
Collie Ridge Northwest	02	402
Collie Ridge Northeast	03	486
Collie Ridge Southwest	04	754
Collie Ridge Southeast	05	481
Temple Hill	06	44
McCoy Hollow West	07	404
McCoy Hollow East	08	260
Peanut Knob	09	161
Turnhole Bend	10	799
Turnhole North	11	79
Onyx Hotel Meadow	12	30
Old Job Corps	13	26
Crystal Cave	14	580
Lick Log	15	585
Flint Ridge West	16	411
Flint Ridge South	17	627
Flint Ridge Southwest	18	367
Crumps Knob	19	109
Brooks Knob	20	91
Jim Lee	21	838

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Name	Unique ID Number	Acres
Mammoth North	22	204
Mammoth South	23	109
Woolsey North	24	722
Woolsey South	25	744
Barrens Chaumont	26	28
Barrens North	27	10
Barrens West	28	81
Barrens East	29	61

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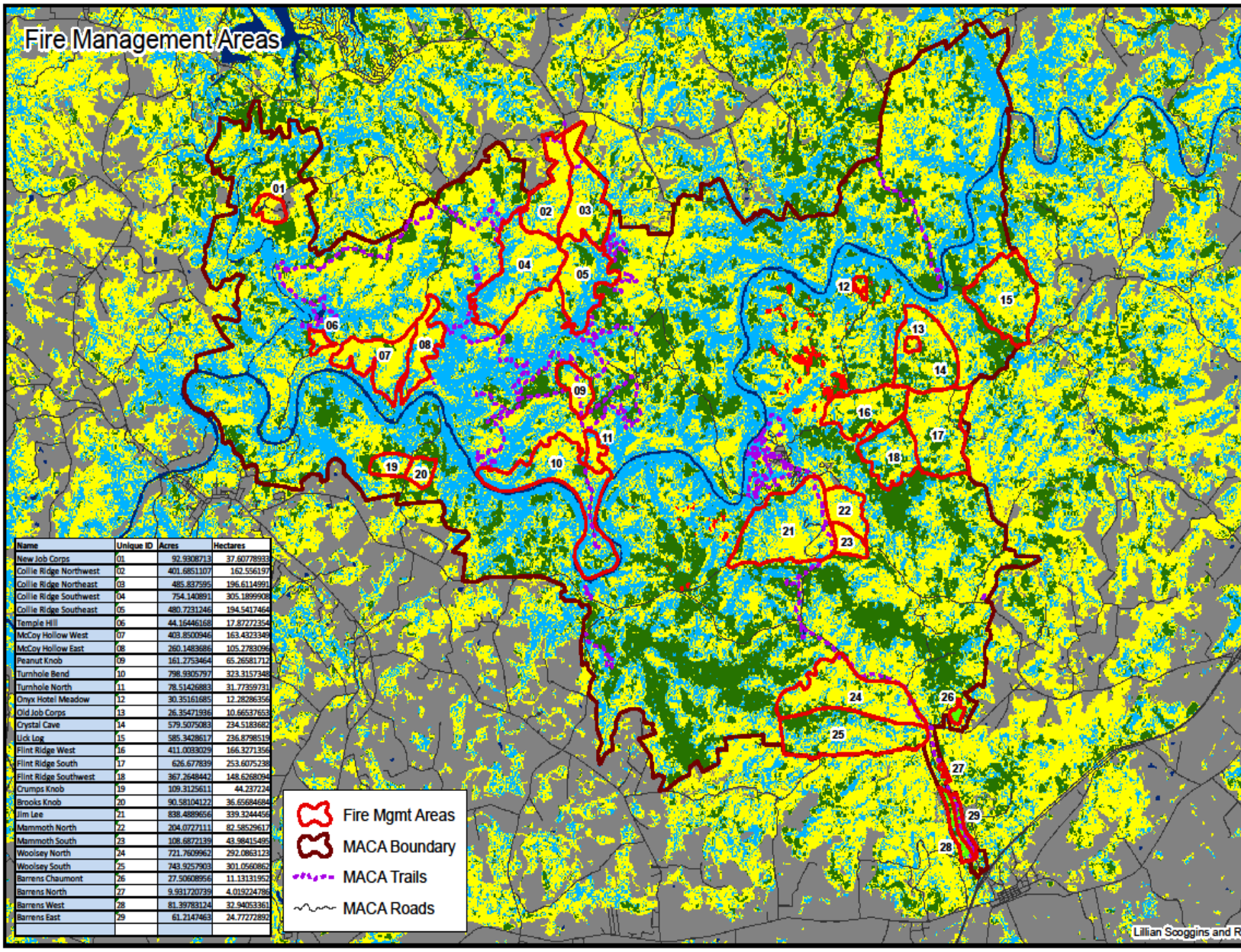
Figure App7-1: Alternative 2 Prescribed Fire Units (Next page)



Name	Unique ID	Acres	Hectares
New Job Corps	01	92.9308713	37.60778933
Collie Ridge Northwest	02	401.6851107	162.556197
Collie Ridge Northeast	03	485.837595	196.6114991
Collie Ridge Southwest	04	754.140891	305.1899908
Collie Ridge Southeast	05	480.7231246	194.5417464
Temple Hill	06	44.16446168	17.87272354
McCoy Hollow West	07	403.8500946	163.4323349
McCoy Hollow East	08	260.1483686	105.2783096
Peanut Knob	09	161.2753464	65.26581712
Turnhole Bend	10	798.9305797	323.3157348
Turnhole North	11	78.51426883	31.77359731
Onyx Hotel Meadow	12	30.35161685	12.28286356
Old Job Corps	13	26.35471936	10.66537653
Crystal Cave	14	579.5075083	234.5183682
Lick Log	15	585.3428617	236.8798519
Flint Ridge West	16	411.0033029	166.3271356
Flint Ridge South	17	626.677839	253.6075238
Flint Ridge Southwest	18	367.2648442	148.6268094
Crumps Knob	19	109.3125611	44.237224
Brooks Knob	20	90.58104122	36.65684684
Jim Lee	21	838.4889656	339.3244456
Mammoth North	22	204.0727111	82.58529617
Mammoth South	23	108.6872139	43.98415495
Woolsey North	24	721.7609962	292.0863173
Woolsey South	25	743.9257903	301.0560862
Barrens Chaumont	26	27.50608956	11.13131952
Barrens North	27	9.931720739	4.019224786
Barrens West	28	81.39783124	32.94053361
Barrens East	29	61.2147463	24.77272892

Appendix 8: Kentucky Species of Concern for Mammoth Cave NP

Category	Scientific Name	Common Names	State Status
Mammal	Corynorhinus rafinesquii	Rafinesque's big-eared bat	KY: S
Mammal	Myotis grisescens	gray bat	KY: T
Mammal	Myotis leibii	eastern small-footed bat	KY: T
Mammal	Myotis septentrionalis	Northern long-eared bat	KY: E
Mammal	Myotis sodalis	Indiana bat	KY: E
Mammal	Nycticeius humeralis	evening bat	KY: S
Bird	Accipiter striatus	Sharp-shinned Hawk	KY: S
Bird	Circus cyaneus	Northern Harrier	KY: T
Bird	Haliaeetus leucocephalus	Bald Eagle	KY: T
Bird	Pandion haliaetus	Osprey, Western Osprey	KY: T
Bird	Lophodytes cucullatus	Hooded Merganser	KY: T
Bird	Fulica americana	American Coot	KY: E
Bird	Pheucticus ludovicianus	Rose-breasted Grosbeak	KY: S
Bird	Certhia americana	Brown Creeper	KY: E
Bird	Junco hyemalis	Dark-eyed Junco	KY: S
Bird	Passerculus sandwichensis	Savannah Sparrow	KY: S
Bird	Dendroica fusca	Blackburnian Warbler	KY: T
Bird	Vermivora chrysoptera	Golden-winged Warbler	KY: T
Bird	Wilsonia canadensis	Canada Warbler	KY: S
Bird	Sitta canadensis	Red-breasted Nuthatch	KY: E
Bird	Cistothorus platensis	Sedge Wren	KY: S
Bird	Thryomanes bewickii	Bewick's Wren	KY: S

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Category	Scientific Name	Common Names	State Status
Bird	Empidonax minimus	Least Flycatcher	KY: E
Bird	Podilymbus podiceps	Pied-billed Grebe	KY: E
Reptile	Elaphe guttata	corn snake	KY: S
Reptile	Eumeces anthracinus	coal skink	KY: T
Fish	Ammocrypta clara	western sand darter	KY: E
Fish	Etheostoma maculatum	spotted darter	KY: T
Fish	Amblyopsis spelaea	northern cavefish	KY: S
Fish	Typhlichthys subterraneus	southern cavefish	KY: S
Vascular Plant	Sagittaria platyphylla	delta arrowhead	KY: E
Vascular Plant	Sagittaria rigida	sessilefruit arrowhead, sessile-fruited arrowhead	KY: E
Vascular Plant	Potamogeton pulcher	heartleaf pondweed, spotted pondweed	KY: T
Vascular Plant	Thaspium pinnatifidum	cutleaf meadowparsnip	KY: T
Vascular Plant	Coreopsis pubescens	hairy coreopsis, start tickseed	KY: S
Vascular Plant	Maianthemum stellatum	star-flower Solomon's-seal,	KY: E
Vascular Plant	Helianthus eggertii	Eggert's sunflower	KY: T
Vascular Plant	Krigia occidentalis	western dwarfdandelion	KY: E
Vascular Plant	Prenanthes racemosa	Purple rattlesnakeroot	KY: S
Vascular Plant	Silphium pinnatifidum	tansy rosinweed	KY: S
Vascular Plant	Symphyotrichum pratense	Barrens silky aster	KY: S
Vascular Plant	Leucothoe recurva	redtwig doghobble	KY: E
Vascular Plant	Dodecatheon frenchii	French's shootingstar	KY: S
Vascular Plant	Lespedeza capitata	roundhead lespedeza	KY: S

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Category	Scientific Name	Common Names	State Status
Vascular Plant	Lespedeza stuevei	Stueve's lespedeza, tall lespedeza	KY: S
Vascular Plant	Rhynchosia tomentosa	twining snoutbean	KY: E
Vascular Plant	Trifolium reflexum	buffalo clover	KY: E
Vascular Plant	Castanea dentata	American chestnut	KY: E
Vascular Plant	Quercus nigra	water oak	KY: T
Vascular Plant	Juglans cinerea	butternut, noyer cerdr, white walnut	KY: S
Vascular Plant	Matelea carolinensis	maroon Carolina milkvine	KY: E
Vascular Plant	Bartonia virginica	yellow screwstem	KY: T
Vascular Plant	Gentiana puberulenta	downy gentian	KY: E
Vascular Plant	Trichostema setaceum	narrowleaf bluecurls	KY: E
Vascular Plant	Aureolaria patula	spreading yellow false foxglove	KY: S
Vascular Plant	Calycanthus floridus var. glaucus	eastern sweetshrub	KY: T
Vascular Plant	Lilium philadelphicum	wood lily	KY: T
Vascular Plant	Veratrum woodii	false hellbore, Wood’s bunchflower	KY: T
Vascular Plant	Viola walteri	prostrate blue violet	KY: T
Vascular Plant	Oenothera perennis	little evening primrose, little evening-primrose	KY: E
Vascular Plant	Carex decomposita	cypressknee sedge	KY: T
Vascular Plant	Carex gigantea	Giant sedge	KY: E
Vascular Plant	Glyceria acutiflora	creeping mannagrass	KY: E
Vascular Plant	Gymnopogon ambiguus	bearded skeletongrass	KY: S
Vascular Plant	Sporobolus clandestinus	rough dropseed	KY: T

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Category	Scientific Name	Common Names	State Status
Vascular Plant	Dryopteris carthusiana	spinulose woodfern	KY: S
Vascular Plant	Agrimonia gryposepala	agrimony, tall hairy agrimony, tall hairy groovebur	KY: T
Vascular Plant	Ulmus serotina	September elm	KY: S
Vascular Plant	Boykinia aconitifolia	Allegheny brookfoam, brook saxifrage	KY: T
Vascular Plant	Vitis labrusca	fox grape	KY: S
Arachnid	Belba bulbipedata	a cave obligate mite	KY: T
Arachnid	Galumna alata	a cave obligate mite	KY: T
Arachnid	Kleptochthonius cerberus	a cave obligate pseudoscorpion	KY: T
Arachnid	Kleptochthonius hageni	a cave obligate pseudoscorpion	KY: S
Arachnid	Macrocheles troglodytes	a cave obligate mite	KY: T
Arachnid	Tyrannochthonius hypogeus	a cave obligate pseudoscorpion	KY: S
Ostracod	Sagittocythere stygia	an ectocommensal ostracod	KY: T
Crustacean	Orconectes pellucidus	Mammoth Cave crayfish	KY: S
Crustacean	Palaemonias ganteri	Kentucky Cave Shrimp, Mammoth cave shrimp	KY: E
Crustacean	Stygobromus vitreus	a cave amphipod	KY: S
Insect	Pygmarrhopalites altus	a cave obligate springtail	KY: T
Insect	Batrisodes henroti	a cave obligate beetle	KY: T
Insect	Pseudanophthalmus audax	bold cave beetle	KY: T
Insect	Pseudanophthalmus inexpectatus	Surprising Cave beetle	KY: T

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Category	Scientific Name	Common Names	State Status
Insect	Pseudosinella espanita	a cave obligate springtail	KY: S
Crab/ Lobster/ Shrimp	Palaemonias ganteri	Kentucky Cave Shrimp, Mammoth cave shrimp	KY: E
Other Non-vertebrates	Margaritifera monodonta	spectaclecase	KY: E
Other Non-vertebrates	Cyprogenia stegaria	fanshell	KY: E
Other Non-vertebrates	Epioblasma torulosa rangiana	northern riffleshell	KY: E
Other Non-vertebrates	Epioblasma triquetra	snuffbox	KY: E
Other Non-vertebrates	Fusconaia subrotunda	longsolid, long-solid	KY: S
Other Non-vertebrates	Lampsilis abrupta	pink mucket	KY: E
Other Non-vertebrates	Lampsilis ovata	pocketbook	KY: E
Other Non-vertebrates	Obovaria retusa	golf stick pearly mussel, ring pink, ring pink mussel	KY: E
Other Non-vertebrates	Plethobasus cyphyus	sheepnose	KY: E
Other Non-vertebrates	Pleurobema clava	clubshell	KY: E
Other Non-vertebrates	Pleurobema plenum	rough pigtoe	KY: E
Other Non-vertebrates	Pleurobema rubrum	pyramid pigtoe	KY: E
Other Non-vertebrates	Toxolasma lividum	purple lilliput	KY: E
Other Non-vertebrates	Villosa ortmanni	Kentucky creekshell	KY: T

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Appendix 9 Federal Species of Concern

Category	Scientific Name	Common Names	Federal Status
Mammal	*Myotis grisescens*	gray bat	Endangered
Mammal	*Myotis septentrionalis*	northern long-eared bat	Threatened
Mammal	*Myotis sodalis*	Indiana bat	Endangered
Fish	*Crystallaria cincotta*	diamond darter	Endangered, unoccupied critical habitat in park
Crab/Lobster/Shrimp	*Palaemonias ganteri*	Kentucky cave shrimp	Endangered, critical habitat in park
Other Non-vertebrates	*Cyprogenia stegaria*	fanshell	Endangered
Other Non-vertebrates	*Epioblasma triquetra*	snuffbox	Endangered
Other Non-vertebrates	*Epioblasma obliquata*	catspaw	Endangered
Other Non-vertebrates	*Lampsilis abrupta*	pink mucket	Endangered
Other Non-vertebrates	*Margaritifera monodonta*	spectaclecase	Endangered
Other Non-vertebrates	*Obovaria retusa*	ring pink	Endangered
Other Non-vertebrates	*Plethobasus cyphyus*	sheepnose	Endangered
Other Non-vertebrates	*Pleurobema clava*	clubshell	Endangered
Other Non-vertebrates	*Pleurobema plenum*	rough pigtoe	Endangered
Other Non-vertebrates	*Theliderma cylindrica*	rabbitsfoot	Threatened, critical habitat in park

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